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Building Category Profile: Warehouse and Light Industrial Buildings

A RESEARCH REPORT

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A RESEARCH REPORT

A Preliminary Study of the
Physical and Energy Consumption
Characteristics of the Warehousing
and Light Industrial Buildings Sector

Sponsored by the
Energy Conservation and Oil Substitution Branch
Energy, Mines and Resources Canada

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under a sub-contract from the
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Waterloo, Ontario

March 1982

BETT Publication No. 82.02

The Buildings Energy Technology Transfer Program (BETT) of EMR has been created to assist building owners, users and practitioners active in the design, construction and operation of buildings in identifying technical obstacles to energy conservation. Through a nationwide network of research agencies and private sector consultants, BETT carries out research and development projects and provides the audiences mentioned above with technical reports, how-to manuals, training manuals, audio-visual aids and data bases to help them overcome these obstacles.

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Cat. No. M91-3/82-02E
ISBN 0-662-12817-6

ABSTRACT/RESUME

Warehouse and light industrial buildings are one of the least researched building categories. This report documents the conduct and results of a study to obtain and analyse available data and then to develop a macro-level profile of this category of Canadian buildings. The intention was to establish the physical and demographic characteristics of the two main sub-categories of building (warehouses, light industrial buildings) and then to assess energy consumption by end use and fuel type.

It was estimated that the total floor space involved is 98.5 million square metres. There are in excess of 66,233 warehouse and light industrial buildings in Canada. Total annual non-process energy used is in the order of 115,000 terajoules.

* * *

Les bâtiments d'entreposage et les bâtiments industriels à structure légère représentant l'une des catégories les moins étudiées. Le présent rapport documente la réalisation et les résultats d'une étude qui devait permettre d'obtenir et d'analyser des données connues et de concevoir un macro-profil de cette catégorie de bâtiments au Canada. L'objectif visé était de cerner les caractéristiques physiques et démographiques de ces deux grandes sous-catégories de bâtiments (les entrepôts et les bâtiments industriels à structure légère), puis d'évaluer la consommation d'énergie en fonction de la vocation du bâtiment et du type de combustible utilisé.

L'étude a porté sur une superficie total estimative de 98,5 millions de mètres carrés. Le Canada compte plus de 66 233 entrepôts et bâtiments de ce genre, et la quantité annuelle total d'énergie utilisée à d'autres fins qu'industrielle est de l'ordre de 115 000 térajoules.

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The Buildings Energy Technology Transfer Program (BETT) was initiated by the Department of Energy, Mines and Resources (EMR) of the Government of Canada in late 1981. The principal objectives of this program are:

- To identify the potential for energy conservation in both new and existing buildings.
- To determine R, D and D requirements and their priority in order to exploit this potential.
- To perform and/or expedite the necessary R, D and D.
- To effectively transfer the necessary technology to the appropriate individuals, groups or agencies.
- To provide technological support to EMR in the development of policy and programs.

The Building Engineering Group (BEG) was selected* by EMR to develop and execute a comprehensive R, D and D program for energy conservation in the Warehousing and Light Industrial Buildings sector. BEG is a semi-autonomous, non-profit agency associated, through the Waterloo Research Institute (WRI), with the University of Waterloo. This multi-disciplinary group attempts to provide a comprehensive range of R and D services to the building industry.

The Warehousing and Light Industrial Buildings sector is particularly important because:

- The square footage of building space encompassed by this category is second only to that of the residential building category.

* DSS Number 02SQ.23380-1-6665-4 Serial OSQ81-00137 and Proposal Number WRI 109-01, September 20, 1981.

- To date very little R and D, energy-related or otherwise, has been directed towards this building category.

- The nature of these buildings, both new and existing, makes them particularly amenable to some degree of energy conservation.

In the initial phase of the R, D and D program developed by BEG, the priorities were to:

- Establish a statistical profile of the warehouse and light industrial building category

- Develop a comprehensive review of the current state-of-practice.

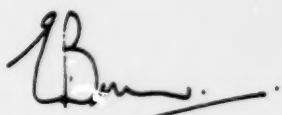
- Initiate the development of a portfolio representative case histories.

Ten related studies are being undertaken in this initial phase, seven of which provide either supporting documentation or input for a comprehensive state-of-practice report.

At the outset it was recognized that the nature, extent and significance of the warehousing and light industrial sector needed to be better categorized and quantified. A statistical profile is necessary for planning purposes (e.g., to establish priorities), for economic purposes (e.g., to assess the significance of energy conservation in this sector), for political purposes (e.g., assessment of the significance of this building category relative to other categories), and for the purposes of technology transfer (e.g., what audiences to address and how best to address them). It was also recognized that a phased approach that, to some extent, developed simultaneously with the overall R and D program would be desirable. This report entitled "Building Category Profile: A Preliminary Study of the Physical and Energy Consumption Characteristics of the Warehousing and Light Industrial Buildings Sector" represents the first

phase in this endeavour. The report was prepared by Stephen Andrew and Vasantha Narasimhan of Peat, Marwick and Partners.

This report is an early product of what is intended to be a concerted multi-year program of research, development, demonstration, dissemination and evaluation. Feedback with regard to the report or related issues is welcome and should be directed to the undersigned.



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Le présent rapport expose les résultats de la phase I d'un projet de recherche et d'analyse documentaire dans le domaine des bâtiments. Il vise à fournir un profil préliminaire du Secteur canadien des bâtiments d'entreposage et des bâtiments industriels à structure légère. Le profil révèle les paramètres et l'aspect physique du Secteur et sert à faciliter la collecte courante de données destinées à soutenir l'élaboration de lignes directrices et de normes en matière d'économies d'énergie, dans le lignes directrices et de normes en matière d'économies d'énergie, dans le cadre d'un programme global de recherche dans ce domaine. Un sondage a permis étudier les sources de données existantes, et les données pertinents connues ont été recuillies on acquises, puis analysées à l'aide des techniques appropriées.

Les résultats de la phase I témoignent de l'importance que revêtent les entrepôts et les immeubles industriels à structure légère sur les plans des dimensions, de la répartitions gépographique et de la consommation d'énergie. C'est sur les données étudiées au cours de la phase I que l'on s'est fondé pour préparer les estimations suivantes, qui ont trait aux bâtiments d'entreposage et aux bâtiments industriels à structure légère.

. Superficie total de l'ordre de:

- 1 060 600 000 pieds carrés
- 98 500 000 mètres carrés.

. Nombre total de bâtiments: 66 233.

. Consommation annuelle total d'énergie servant à d'autres fins qu'industrielle, de l'ordre de:

- 115 000 térajoules

- 32 000 000 MWh.

Les entrepôts visés dans l'étude représentent une superficie total de 648 594 000 pieds carrés, soit 60 255 000 mètres carrés. On a estimé à 48 441 le nombre total d'entrepôts et à 70 048 térajoules ou 19 457 824 MWh leur consommation totale annuelle d'énergie. Environ 84% de ces bâtiments étaient répartis entre l'Ontario, le

Québec, la Colombie-Britannique et l'Alberta. Ils servent principalement à l'entreposage de marchandises sèches (81,6%).

Les bâtiments industriels à structure légère représentent une superficie total estimée à 412 008 000 pieds carrés. On a estimé à 17 792 le nombre total de bâtiments industriels à structure légère et à 45 593 térajoules ou 12 664 759 MWh la quantité d'énergie que ces bâtiments utilisent à d'atures fins qu'industrielle, notamment à des fins de chauffage, d'éclairage et de ventilation. Ils étaient surtout (77,4%) situés dans le provinces de l'Ontario et de Québec. Les principales industries prises en considération étaient celles du bois, de la machinerie, des appareils électriques, de l'imprimerie et de l'édition, de la fabrication des métaux* ainsi que diverses autres industries.

Les estimations qui précédent sont limitées par:

le manque de données,

le fait que les données connues sont de nature globale, rattachées à un macro-profil

l'emploi de méthodes d'estimation indirectes,

les extrapolations exécutées.

Une déscription de ces limites ainsi que de leur incidence potentielle sont comprises dans le présent rapport.

La répartition selon les dimensions ainsi que l'âge des entrepôts et des bâtiments industriels à structure légère ont été étudiés. D'atures analyses ont porté sur les fins auxquelles l'énergie est consommée ainsi que sur la répartition des bâtiments selon le type de source d'énergie et le type d'installation de chauffage. Les études en fonction de la répartition n'ont parfois porté que sur les bâtiments d'entreposage ou sur les bâtiments industriels à structure légère, tout dépendant de la disponibilité des données.

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* Seule l'industrie légère des grands secteurs industriels que sont ceux du bois et de la fabrication des métaux est prise en considération.

This report describes the initial phase of a planned process for obtaining and analyzing data on buildings comprising the Warehousing and Light Industrial Buildings sector. Warehousing and Light Industrial Buildings are one of the least researched building categories in Canada. Consequently, the first task in data collection has been the development of a macro-level profile of the sector to provide a clear indication of the magnitude and distribution of its key elements.

The information in this report is of two generic types:

- Physical Data relating to the stock of warehousing and light industrial buildings in Canada.
- Energy consumption data relating to the building stock identified.

Both types of data are required by members of the project team engaged in the development of standards and guidelines for energy conservation in the Warehousing and Light Industrial Buildings sector. The physical and energy consumption statistics contained in this report provide an overview of the parameters of the sector. They will, therefore, facilitate both the development and eventual implementation of conservation measures by enhancing the quality of planning being undertaken to establish and assess the relative merits of alternative measures identified.

The building stock data contained in this report represent stand-alone information. Preparation of such macro-level information has been undertaken, however, with the knowledge that extensive, primary data in a disaggregated form are likely to be required as the project proceeds. In that context, this report represents the first phase of data collection. Further details of the overall data collection process, and its first phase in particular, are provided below.

The phased collection of data in support of energy conservation studies of building sectors is an

EXHIBIT 1

GENERIC CHARACTERISTICS OF THE THREE PHASES OF BUILDING ENERGY CONSERVATION DATA COLLECTION

Phase 1

Data/ Information Sources

- Existing data banks.
- Field experts.
- Documented reports.

Building Characteristics

Macro Data on:

- Number of buildings and/or floor space.
- Location.
- Age.
- Total fuel consumed.
- Broad end use consumption.

Methods

- Data collection from existing sources.
- Analysis of macro data using:
  - estimation techniques
  - allocations
  - distribution analyses.

End Product

General Profile of Sector:

- Total floor space.
- Total energy consumption.
- Macro distributions of floor area and energy consumed by age, size, location, broad sub-categories, fuel end-use and/or fuel types.

Phase 2

Data/ Information Source

Actual building owners/users.

Building Characteristics

Empirical Data on Buildings:

- Location (address, province, region, etc.)
- Age (date of construction).
- State of building.
- Use of building.
- Use related area.
  - warehouse
  - plant
  - office
  - other.
- Dimensions (length, breadth, height).
- Enclosure.
- Loading docks.
- Doors/Windows/Wall area.
- Types of heating/air conditioning/ ventilation systems.
- Level of lighting.
- Hours of occupancy.
- Consumption by fuel types.
- Ownership.

Methods

- Data Collection through sampling using mailed questionnaire.
- Analysis using statistical techniques.

End Product

- Identification of key sub-categories.
- Profile of key sub-categories.
- Definition of representative buildings in key sub-categories.

Phase 3

Data/ Information Source

Actual building owners/users.

Building Characteristics

Empirical Micro data on:

- Technical characteristics of buildings
  - exterior walls
  - roofs/doors/windows
  - HVAC systems
  - lighting systems
  - temperature control
  - equipment usage.
- Ownership/Management.
- Energy consumption and metering.
- End uses of energy.
- Energy conservation practices.
- Attitudes.
- Usage patterns.
- Hours of occupancy.

Methods

- In-depth interviews of owners/users of a limited number of representative buildings.
- Technical and statistical analyses.

End Product

Analysis of technical, administrative and marketing parameters leading to the design of:

- Energy conservation guidelines/standards.
- Incentives.
- Information for dissemination.

established practice. The key characteristics of the different phases of data collection are presented in Exhibit 1, opposite.

The exhibit shows that from Phase I to Phase III there is an increasing emphasis on the:

- Disaggregation of data.
- Detail of data.
- Quality of data.
- Relevance to the specific energy conservation activities of the overall study.

STUDY OBJECTIVES

The current study represents Phase I of the three generic phases of data collection described in Exhibit 1. The objectives of the Phase I study are:

1. To collect macro level data on general characteristics of warehousing and light industrial buildings from existing sources.

2. To analyze the data and provide a preliminary profile of the building sector and its major sub-categories in terms of:

   - Physical characteristics - location, age, number of buildings and floor space.
   - Energy consumption - by end-use and/or fuel types.

3. To identify gaps in the current state of knowledge about the sector and outline briefly the tasks that remain to be completed.

The results of Phase I are intended to support the development of the overall conservation project and to provide the basis for Phase II data collection. Through the use of sampling techniques in Phases II and III, more relevant and detailed data will be gathered to refine, amplify and complete the general profile of buildings developed in Phase I.

SCOPE OF PHASE I

This sub-section describes the sectoral boundaries established for Phase I, the tasks involved, and their relationship to Phase II.

Building Sector Boundaries

The boundaries and components of the Warehousing and Light Industrial Buildings sector are not as clearly established as those of the Residential or Office Building sectors because the extent of research has been relatively limited in comparison to other major building sectors.

The task was to define a study of building categories that would be meaningful in terms of the study objectives and also be practical in terms of obtaining data for stock estimations in Phase I. The task of defining a study set was undertaken in five steps:

1. Identification of a universe of building categories.

2. Elimination of those buildings that are definitely out-of-scope.

3. Examination of the residual set to determine a conceptual set of building categories and sub-categories.

4. Assessment of the feasibility of data collection on the categories and/or

EXHIBIT 2

DERIVING A SET OF SERVICE INDUSTRIAL BUILDINGS FOR THIS STUDY

THE UNIVERSE OF BUILDING CATEGORIES - STEP 1

RESIDENTIAL

- Single Detached
- Single Attached
- Low-Rise Multiple Units
- Medium/High-Rise Multiple Units

INSTITUTIONAL

- Hospitals
- Schools
- Colleges
- Universities

COMMERCIAL

- Office
- Retail
- Hotels and Motels
- Basic Storage (C)
- Basic Warehousing (C)
- Cooler Warehousing (C)
- Freezer Warehousing (C)
- Mixed Service (C)

INDUSTRIAL/PROCESS

- Heavy Manufacture/Assembly
- Fabrication
- Forming
- Refining
- Chemical
- Power Generating
- Smelting
- Crushing
- Light Manufacture/Assembly
- Basic Storage (I)
- Basic Warehousing (I)
- Cooler Warehousing (I)
- Freezer Warehousing (I)
- Mixed Service (I)

SUB-CATEGORIES THAT ARE CONCEPTUALLY PART OF SERVICE INDUSTRIAL BUILDINGS

STEPS 2 AND 3

- Basic Storage (C)
- Basic Warehousing (C)
- Cooler Warehousing (C)
- Freezer Warehousing (C)

Mixed Service (I and Part of C)

- Light Manufacture/Assembly
- Basic Storage (I)
- Cooler Warehousing (I)
- Freezer Warehousing (I)

SERVICE INDUSTRIAL BUILDINGS INCLUDED FOR THIS STUDY

STEPS 4 AND 5

Warehousing

- Basic Storage (C+I)
- Basic Warehousing (C+I)
- Cooler Warehousing (C+I)*
- Freezer Warehousing (C+I)*

Light Industrial

- Light Manufacture/Assembly

* Statistics Canada has named these categories as Refrigerated Storage-Cooler and Refrigerated Storage-Freezer in Publication 61-212

sub-categories of the conceptual set of service industrial buildings.

5. Definition of a study set that would include as many categories and sub-categories of the conceptual set of service industrial buildings as possible, given the practicality of obtaining data.

Exhibit 2, on reverse, illustrates the above steps. Step 1 resulted in a universe of building categories, steps 2 and 3 together resulted in a conceptual set of service industrial buildings, and steps 4 and 5 provided a study set of service industrial buildings. From Exhibit 2, it is clear that steps 2 and 3 resulted in the elimination of the residential category as a whole from the universal set and some sub-categories of the commercial and industrial/process groups to provide a conceptual set of service industrial buildings.

Exhibit 2, also indicates that steps 4 and 5 resulted in a study set which excluded all mixed service buildings from the conceptual set. The exclusion of the mixed service buildings was based on the opinions of inventory data gatherers at assessment offices, real-estate firms and Canadata. They pointed out the impracticality of gathering data on a subset which consists of a large number of small and disparate entities that are often mixed up with the retail sector. Thus, even though these mixed service buildings are a legitimate part of the service industrial sector, they were excluded for practical reasons from our initial estimates of floor-space, number of buildings, and energy consumption.

The study set of service industrial buildings for stock estimations of Phase I was seperated into warehousing buildings and light industrial buildings. The buildings included and excluded from these groups are elaborated below.

The study set of warehousing buildings included basic storage, cooler and freezer warehouses of both industrial and commercial sectors. Excluded from the group were buildings such as grain elevators,

silos, utility buildings (buildings housing telephone, telegraph and cable equipment), hangars and parking buildings. That exclusion was based on technical advice concerning their peculiar design characteristics and energy requirements. Vehicle storage buildings, such as those used for storage and maintenance of buses, were excluded because of the difficulty of obtaining data. Further research must be undertaken to assess the total floor space and energy requirements of vehicle storage buildings that form a legitimate part of the Warehousing and Light Industrial Buildings sector.

The light industrial buildings included those used for manufacturing/assembly operations. It excluded buildings that appeared to fall within the retail services, such as shoe-repair, barber or beauty shops, laundry/dry-cleaners, blacksmiths and welding shops. It also excluded motor vehicle service buildings because it was felt that the energy consumption patterns of service garages with little draught control would be significantly different.

The Phase I inclusions and exclusions discussed above were sufficient to operationalize research on warehousing. In the case of light industrial buildings, however, it was necessary to use an evaluation framework based on non-process/process energy use indicators to separate the light industries from heavy industries. A detailed description of this procedure is provided in Appendix 2. In summary, it involved ranking each major industrial group on the basis of the percentage of energy consumed for space heating and lighting, and the percentage of energy consumed for make-up air (energy used for replacing air contaminated with dust and particles with clean, heated air). The energy consumption data for the ranking process was obtained from the two reports of Ontario Hydro (PMA 75-6, 76-1) synthesized by MacDonald, Desfor and Miloff (1979). The sum of the ranks obtained by each industrial group on the two indicators were converted into ratings using a multiplier. The combined ratings were used to distinguish light from heavy industries.

The results were also verified using the definition of light industries found in zoning by-laws. This analysis resulted in the inclusion of nine major

industrial groups in total and three major groups in part. The nine major industrial groups completely included were:

- Tobacco
- Leather
- Knitting Mills
- Clothing
- Furniture and Fixtures
- Printing, Publishing and Allied Concerns
- Machinery
- Electrical Products
- Miscellaneous.

The three major groups that were partially included, after removing those industries that were found to be process energy intensive, are identified below. The asterisks are used throughout this report to indicate that the major groups so marked are as redefined below, rather than the entire major groups:

- Textile* (includes only cordage and twine, canvas products and miscellaneous textile)
- Wood* (includes only sash, door and millwork, and miscellaneous wood)
- Metal Fabricating* (includes only machine shops, fabricated structural metal, ornamental metal and miscellaneous metal fabricating).

The identity of SIC (Standard Industrial Classification) groupings was retained in order to permit maximum flexibility in using the macro data available from Statistics Canada and similar sources which code aggregate data by the SIC.

Tasks of Phase I

Phase I is the exploratory data collection phase of an on-going research project. Consequently, a considerable amount of time was spent on the following tasks:

1. Locating published research papers, reports, case histories, and surveys relating to the sector.

2. Contacting experts or officials from federal and provincial government departments, agencies, assessment offices, utilities, municipal planning boards, real estate firms, associations, engineers, and private (commercial) data banks to determine:

   - types of data and information in existence
   - extent of disaggregation possible
   - availability of data
   - retrievability of data for the current phase or in the future
   - limitations of data, if known.

3. Examining the information elicited through data sourcing to study the feasibility of developing a preliminary profile using available data.

4. Following up the feasibility study with:

   - specification of data to be purchased or extracted
   - design of appropriate estimation techniques, allocation procedures, and analytical methods to develop a preliminary sectoral profile.

5. Collecting specified data and analyzing them using the methods envisaged.

6. Reporting initial findings.

7. Providing an overview of the major tasks of Phase II.

Interface with Phase II

The findings of Phase I were expected to provide a general profile of the sector by describing:

- Extent of floor space of buildings in the sector
- Distribution of building floor space by province and by period of construction
- Energy consumption amounts by fuel types and/or end-use
- Significance of a warehouse sub-category or light industrial group
- Other characteristics such as size distribution or heat-type distribution even if restricted to a segment of the total stock of buildings in the sector.

This preliminary information about the sector, together with an awareness of the nature of additional data and information sources unavailable during Phase I, was expected to serve as the basis for launching an appropriate sampling study in Phase II.

METHODOLOGY FOR PHASE I

In order to reach the objective of providing a preliminary profile of buildings in the Warehousing and Light Industrial Buildings sector, within the time frame and budget allowed, it was evident that the macro approach, using existing data, was most

suitable. Accordingly, a thorough search of all existing data sources was conducted. Initial leads were generated through our previous experience in developing profiles of building sectors, from discussions with other project team members, and from literature reviews. Subsequently, telephone enquiries, letters of request and personal interviews were extensively used. A list of contacts is contained in Appendix 3.

The techniques used to convert available data into useful information included basic economic and statistical analyses, conversions, estimations, allocations, and determination of distributions. The validity of results was checked through verification procedures including reference to results derived from different sources and computation of results using alternate techniques.

Appraisal of Methodology

Phase I methodology was based on optimization of existing data for analysis and distillation of relevant information. The sourcing and analysis of existing data has several benefits over the collection of original information. The principal benefits are that:

- It can be undertaken for a reasonable cost in a short period of time.
- It is helpful in determining gaps in existing data so that they can be filled in the future by appropriate surveys and sampling procedures.
- It prevents redundant and costly gathering of data that may already exist.
- It assists in ranking future areas of research through an early assessment of the significance and scope of broad sub-categories at the macro-level.

This method has its limitations, however, particularly if existing data is in an aggregated form, incomplete, or of poor quality. The tasks planned

for Phases II and III are expected to compensate for such problems. In Phase II, we envisage gathering empirical and other relevant data, from a large sample of building owners/users through the use of telephone interviews and mailed questionnaires. In-depth personal interviews with owners/users of a small, representative sample of buildings during Phase III is expected to provide the necessary specific data likely to be required by the technical groups in the overall project team. The incremental, phased approach is appropriate in that more sophisticated and expensive methods are employed only after an appropriate level of understanding of the physical and energy consumption characteristics of the sector has been acquired, and after the technical requirements of other project teams have been more precisely defined.

This section outlines the kinds of data that were considered essential for the development of a preliminary profile of warehousing and light industrial buildings. It also makes reference to an extensive data sourcing survey that was conducted. Finally, it provides an overview of the sub-categories used to group the available data.

DATA REQUIREMENTS

The identification of data requirements was necessary to provide a point of reference for the data sourcing survey.

Physical Data Requirements

The basic physical data elements considered necessary for the development of a reasonably complete preliminary profile were the total floor area and number of buildings classified by geographic location, building age groups, and the types of light industrial or storage activity undertaken. However, if additional data, such as types of heating systems and sizes of buildings were available, these were also to be analyzed and incorporated in the preliminary profile.

The initially agreed data requirements resulted from an examination of their relevance both to the immediate (Phase I) objective of developing a preliminary profile of buildings in the sector, and to the ultimate (Phase III) objective of designing energy conservation guidelines. The relevance of the physical data points is briefly outlined below.

Floor Space

This was considered the only statistic likely to be available on a comprehensive basis (although other measurements such as height or volume will be additional useful measures). Floor space data will facilitate:

- Comparison of age group, locational, or use/activity sub-categories in terms of their relative scope and significance.

- In the absence of energy consumption data, conversion of floor space data into total energy consumption figures. Such conversions are predicated on appropriate coefficients of energy use per unit area being available by type of building and activity.

Number of Buildings

This data would facilitate:

- Estimation of the average size of buildings where direct data on size of buildings is not available.

- Derivation of statistically valid sample sizes for Phase II.

- Determination of the number and nature of users or owners to whom information concerning energy conservation standards and guidelines may have to be disseminated.

- In conjunction with data on age, estimation of the number of buildings that might be retrofitted.

Location

Data on the geographic location of buildings would be helpful in:

- Identification of the concentration of the sector buildings in certain locations, thus narrowing the geographic scope of future research.

- Assessment of the relative worth of different geographic segments to enable targeting the key segments for program dissemination and delivery.

- Application of energy models that usually incorporate considerations of heating and cooling degree days.

Age

The age of buildings is a key variable affecting both energy consumption and conservation potential. Data on the age of buildings would assist in:

- Aggregation of buildings by different periods of construction that are distinctive in terms of certain design features or building codes governing each period.

- Application of energy consumption coefficients per unit area that are differentiated by age of building, when such coefficients become available through future research.

- Incorporation of demolition rates in building stock calculations, if such rates become available through future research.

- Assessment of the potential benefit of directing certain conservation guidelines towards buildings belonging to specific age groups.

- Identification of buildings that might be retrofitted and an assessment of the potential energy savings that might accrue through retrofit.

Activity/Use

Data on the kind of activity undertaken within a building, for example, dry storage versus freezer storage or clothing manufacture versus metal fabricating, are crucial to the development of a

sectoral profile, particularly the energy profile. As indicated in the sub-section on Sectoral Boundaries, space heating, lighting, make-up air, process, motor, and other end uses of energy will depend on the activity undertaken within a building. Similarly, the total energy consumed will also depend on the activity.

Supplementary Data

This category would include any relevant data that may be available and provide a better understanding of the sector. The size of individual buildings to develop size categories or heating types installed in buildings are examples.

Energy Data Requirements

The energy data requirements were conceived in a hierarchical manner. For example, total energy consumed in terajoules or kilowatt hours was considered indispensable. In the absence of direct consumption data, it was anticipated that review of case studies, discussions with federal or provincial energy conservation departments and/or consultation with field experts would provide coefficients to be applied to one or more sub-categories of buildings within the sector.

The next most desirable data category was the amount of energy consumed for different end-uses:

- space-heating
- lighting
- make-up air
  (replacing contaminated air with cleaned and heated air)
- process

- water heating
- auxiliaries.

The end-use analysis was expected to highlight significant areas of energy consumption, and therèfore indicate significant areas of conservation, given that in most warehouses and light manufacturing industries, building energy conservation has been a much neglected issue. (Ontario Hydro, 1981.)

Lastly, a break-down of energy consumption by fuel types was also expected to be extremely helpful in designing incentives to encourage substitution of alternate fuels as dictated by supply and demand characteristics of various fuel types and the needs of the particular industry.

DATA SOURCING

Data sources were identified and enquiries were made to ascertain: the relevance of existing data for the development of a sectoral profile; the suitability of the existing source classification for our study; the retrievability of data (manual versus automated); and the availability of the data within the time horizon of the current study and subsequent to it.

A detailed narrative of the results of the data sourcing survey is provided in Appendix 4. This Appendix will be of use in undertaking further demographic research to develop and refine the sectoral profile presented in this report.

The data sourcing survey helped in identifying existing data sources accessible during Phase I. The available and relevant sources were:

- Canadata and Statistics Canada for Physical Data.

- Statistics Canada, the Ontario Ministry of Energy, Moffat Engineering Limited, and Ontario Hydro for Energy Data.

The nature of data collected is described in Appendix 5.

DATA DISAGGREGATION

Disaggregation is an approach that allows the analysis of data points pertaining to a building sub-sector. The sub-categorization of a building sector into meaningful entities that share distinctive energy consumption characteristics or energy conservation potential is of fundamental importance in the development of an effective conservation program. For example, it is desirable to study dry storage warehouses separately from freezer storage warehouses in order to determine their respective sizes, fuel consumption characteristics and barriers to conservation. However, what is desirable in terms of sub-categorization may not be feasible. Several constraints exist with respect to the availability and quality of existing data, and the feasibility of collecting both new and existing data.

Our choice of sub-categories for Phase I analysis was based on:

- the objectives of Phase I
- data availability
- preliminary knowledge about the sector.

The major sub-categories developed were age, location, size, and activity/use. The data points analyzed for each of these sub-categories were floor area and number of buildings, total energy consumption and energy consumption by end-use with fuel types where possible. The sub-categories chosen are described below.

Age Groups

The choice of age groups or periods of construction was based on expert advice about trends in building design and changes in building codes as well as the peculiarities of data sources.

The pre-1956 stock for the warehouse sector was separated from the rest because around this time warehouses having more than one storey were on the decline, giving place to larger, suburban, single-storey buildings. The 1979-1981 part of the stock was studied as a separate group because the energy conservation potential in more recent buildings was expected to differ from earlier periods. The 1956-1979 portion could have remained as one period since initial enquiries indicated that there were no major changes in building trends or technology. However, it was necessary to split the group into 1956-1974 and 1974-1978 because the year 1974 corresponds with the commencement of automated data bases such as that of Canadata and, therefore, will often be the starting point for analyses of disaggregated data of better quality.

The same age categories were used for the light industrial groups with the exception that 1961 instead of 1956 was chosen as the first cut-off point. This change was due to the fact that Statistics Canada's time series on the value of investment in light industrial buildings only goes back to 1961.

Location Sub-Categories

In most of our analysis, provinces were chosen as the unit. Occasionally, when the numbers were too small, the Atlantic provinces have been grouped together. The province as a unit of analysis is most convenient because it could be aggregated into, say, climatic regions or broken down further for administrative purposes in future research. Previous work by Scanada Consultants in the housing sector has shown a close correspondence between climatic zones based on heating degree days and provincial agglomerations.

Size Groups

The size categories were chosen in consultation with real estate boards. The structural characteristics and cost of constructing warehousing and light industrial buildings are usually functions of their size.

The size groupings chosen were:

- up to 928 m^2 (less than 10,000 f^2)
- 929 m^2 to 1857 m^2 (10,000 to less than 20,000 f^2)
- 1858 m^2 to 4644 m^2 (20,000 to less than 50,000 f^2)
- 4645 m^2 to 13935 m^2 (50,000 to less than 150,000 f^2)
- above 13935 m^2 (greater than 150,000 f^2)

Activity/Use Groups

A breakdown of warehousing was based on the type of storage - dry, cooler and freezer - since each can be expected to have different envelope requirements and specialized energy usage characteristics.

The light industries were broken down by their industrial group and within groups. This was based on the reasoning that the end-use patterns of energy consumption will vary among groups.

Limitations of Current Level of Disaggregation

Although categories were developed and data analyzed for each sub-category, the lack of disaggregated data, (except for the period 1974-1981 covered by Canadata's custom report), rendered the analysis less than ideal. However, the sampling methods envisaged for Phase II are expected to overcome most of the deficiencies stemming from lack of appropriately disaggregated data in Phase I.

This section provides a physical profile of building groups comprising the sector. The development of a physical profile of service industrial buildings comprising the Warehousing and Light Industrial Buildings Sector is an important goal of a demographic study of buildings. Details on the number of buildings, the total floor space occupied by them, their distribution by age, location, activity and size groups are considered helpful in several respects. Some examples of tasks that could be assisted by physical details are: evaluation of the relative significance of specific sub-categories; estimation of energy consumption of buildings of the sector when direct data is not available; assessment of the extent and potential advantages of retrofit; identification of significant locations, age groups and activity groups, for subsequent research; and disaggregation of data in future.

Actual building inventory data was not available for Phase I. Our stock figures and distribution patterns for the delineation of physical profiles were, therefore, derived through estimates using direct and indirect macro data. Three major streams of estimates were developed using data collected from various sources:

- Stock of warehouse floor space by province and by periods of construction
- Stock of floor space of light industrial buildings at a national level and in two key provinces by period of construction
- Distribution of warehouse floor space in three categories: dry storage, cooler storage, and freezer storage.

In addition to the above estimates, the disaggregated data available for warehouses and light industrial buildings constructed in the years 1974-1981 have been analyzed to determine the:

- Percentage distribution of warehouse and light industrial buildings by size categories

- Percentage distribution of warehouse floor space classified by type of heating used.

The methods used, the estimated results, and the limitations of the estimates are presented below.

STOCK DATA (FLOOR SPACE AND NUMBER OF BUILDINGS)-WAREHOUSING

Floor space data was particularly important for the warehousing and storage buildings because it served as a basis for estimating the total energy consumption of these buildings. Its use in identifying significant sub-categories by location, age and activity was also recognized.

The number of buildings figure was estimated from floor space data. An estimate of the number of buildings was expected to be helpful in establishing the size of a statistically valid sample for future studies, and in assessing the potential number of owners/ users that must be reached to effect conservation measures.

Method to Estimate Warehousing Floor Space and Number of Buildings

This method used data from several sources (See Appendix 5). The estimation procedure consisted of the following steps undertaken for each province:

1. Estimating a time series of low, medium and high costs per square foot of warehouse construction with expert advice, use of average per square foot 1982 costs, and an appropriate price index to establish cost in current dollars for the years 1956-1981 (Appendix 7).

2. Dividing the value of warehouses constructed in a province (Statistics Canada's Construction in Canada Data) in a particular year by low, medium, and high costs per square foot for the year to obtain an estimate of warehouse floor space. Repeating the calculations for each of the years 1956-1981.

3. Finding the category of square foot cost (low, medium or high) that produces a floor space estimate for the years 1974-1981 that is close to the actual floor space data compiled by Canadata for the same period.

4. Estimating the stock of warehouses built prior to 1956 by using the assumption:

$$\text{Gross Stock at the end of 1981} = \text{Gross Stock (end of 1955)} + \sum_{1956}^{1981} \text{annual additional construction}$$

Since annual additional construction data from 1956-1981 was available, it was possible to estimate the stock of warehouses at the end of 1955, by finding the proportion, S, in a comparable sector where

$$S = \frac{\text{stock of buildings at the end of 1981}}{\text{stock of buildings at the end of 1955}}$$

Because warehouses are constructed mainly by manufacturing industries and the trade sector, the proportion S for these two sectors was expected to produce a close surrogate for the S of the warehousing sector. The manufacturing industries and trade sectors had S's that varied only slightly from each other. Hence, an average of S(Trade) and S(Manufacturing) was taken to represent S(Warehousing) for each province (data from Fixed Capital Flows and Stocks).

5. Calculating the pre-1956 stock using the formula:

$$\text{Gross Stock (end of 1955)} = \sum_{56}^{81} \frac{\text{annual additional square footage of warehouses}}{S - 1}$$

EXHIBIT 3

WAREHOUSING: ESTIMATED NUMBER OF BUILDINGS AND FLOOR AREA BY PROVINCE

PROVINCE	NUMBER OF BUILDINGS		FLOOR SPACE		
	NUMBER	PERCENTAGE	1000 f^2	1000 m^2*	PERCENTAGE
Nova Scotia	1,322	(2.7)	14,274	1,325	(2.2)
New Brunswick	1,317	(2.7)	16,993	1,579	(2.6)
Newfoundland and P.E.I.	1,747	(3.6)	10,306	958	(1.6)
Quebec	12,987	(26.8)	140,255	13,030	(21.6)
Ontario	13,721	(28.3)	226,394	21,032	(34.9)
Manitoba	2,403	(5.0)	32,926	3,058	(5.1)
Saskatchewan	3,755	(7.8)	29,287	2,721	(4.5)
Alberta	4,784	(9.9)	90,413	8,400	(13.9)
B.C.	6,405	(13.2)	87,746	8,152	(13.5)
TOTAL	48,441	(100)	648,594	60,255	(100)

* 1 square foot = 0.092903 square metre.

6. Summing the pre-1956 stock and the annual additions from 1956-1981 to provide the total stock of warehousing floor space in each province.

7. Dividing the total floor space estimated for each province by average size of warehousing building in the province (Canadata's custom report) to obtain the total number of buildings in each province.

Estimated Stock Data - Warehousing

Based on the information available and the procedures detailed above, Canadian warehousing buildings were estimated to occupy a total floor space of 649 million square feet and the total number of buildings were estimated to be over 48,000, as shown in Exhibit 3, opposite. The exhibit demonstrates that Ontario, Quebec, Alberta and British Columbia together have 84% of the total stock of warehouse floor space. The highest concentration of warehousing floor space is in Ontario (34.9%), followed by Quebec (21.6%), Alberta (13.9%) and B.C. (13.5%). These four provinces also have about 78% of the total number of warehousing buildings.

Exhibit 4, overleaf, provides a profile of warehouse floor area estimated by province and by age. With regard to floor space distribution by period of construction, the gross stock is more or less evenly distributed between the pre-1956 period (40.3%) and the 1956-1973 period (31.5%). The more recent structures of the periods 1974-1978 and 1979-1981 together constitute 28.2% of the total gross floor area.

EXHIBIT 4

DISTRIBUTION OF FLOOR AREA OF WAREHOUSES IN THE PROVINCES OF CANADA* CLASSIFIED BY PERIOD OF CONSTRUCTION

PROVINCES	PERIOD OF CONSTRUCTION									
	Pre 1956		1956-1973		1974-1978		1979-1981		Total	
	1000 ft^2	1000 m^{2**}	1000 ft^2	1000 m^2	1000 ft^2	1000 m^2	1000 ft^2	1000 m^2	1000 ft^2	1000 m^2
Nova Scotia	4,482	416	5,289	491	2,434	226	2,069	192	14,274	1,325
New Brunswick	6,735	626	5,725	532	3,206	298	1,327	123	16,993	1,579
Newfoundland & P.E.I.	5,002	465	3,051	283	1,148	107	1,105	103	10,306	958
Quebec	65,090	6,047	46,214	4,293	21,019	1,953	7,932	737	140,255	13,030
Ontario	100,634	9,349	74,469	6,918	28,101	2,611	23,190	2,154	226,394	21,032
Manitoba	12,456	1,157	11,833	1,099	5,149	478	3,488	324	32,926	3,058
Saskatchewan	12,961	1,204	8,684	807	2,978	277	4,664	433	29,287	2,721
Alberta	21,093	1,960	20,882	1,940	20,811	1,933	27,627	2,567	90,413	8,400
British Columbia	32,730	3,041	28,475	2,645	13,881	1,290	12,660	1,176	87,746	8,152
TOTAL*	261,183	24,265	204,622	19,008	98,727	9,173	84,062	7,809	648,594	60,255

* Data for Yukon and the Northwest Territories was incomplete and, therefore, excluded from analysis

** 1 square foot = .092903 square metre

Limitations to the Estimated Floor Space and Number of Warehousing Buildings

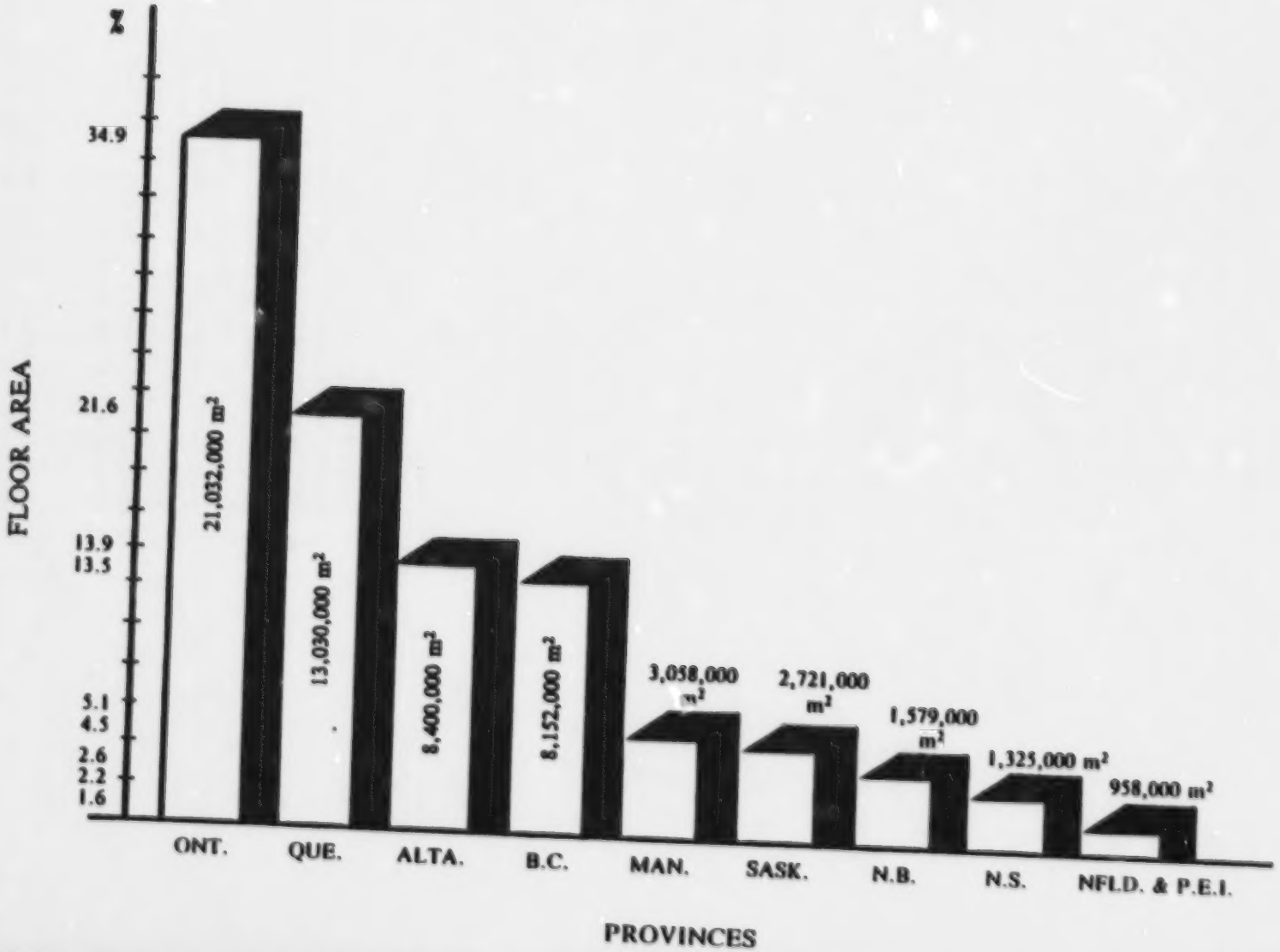
The following qualifiers to the stock estimates are provided to emphasize the fact that the numbers are not totals of primary inventory data. Several limitations to the accuracy and validity of the estimates arise from the kind of data used and the methods employed. In most cases, it is not at present possible to gauge whether the limitations have affected our estimates positively or negatively nor to provide an indication of the extent of any variance. It is possible that errors may balance out to an insignificant difference for any given data category. The purpose of providing the following information is to specify the weaknesses in order to define the problems and indicate the need to refine, confirm and/or correct the estimates when possible, and where they are deemed to be strategically significant to the ongoing sector project.

The floor space estimate was based on the dollar value of construction reported in Statistics Canada's publication, and a low, medium, and high series of construction costs per square foot estimated for the years 1956-1981. The published source for value of construction is an aggregate source and, therefore, suffers from the rigidity and lack of precision that usually accompany aggregate source data. As for the construction costs per square foot, they suffer from being national averages whereas in the real world actual costs differ from one region to another. Thus, despite the use of expert advice and careful judgment, the conversion of dollar values into square footage cannot be expected to produce accurate results. However, the method is likely to produce reasonable first-cut, macro-level estimates. A confirmation to this effect was obtained from the fact that the conversion of the value of warehousing construction into floor space for the years 1974-1981, using the medium per square foot cost series (Appendix 7), produced a number close to the total floor space data accumulated on a building by building basis by Canadata for the same period.

Another limitation of the method stems from the employment of an indirect procedure for estimating

EXHIBIT 4A

DISTRIBUTION OF FLOOR AREA OF WAREHOUSES IN THE PROVINCES OF CANADA



the pre-1956 stock of warehousing buildings. The use of an average figure from the trade and manufacturing sectors for the proportion of 1981 building stock to 1956 building stock is likely to introduce some errors in the estimates.

The estimation procedure did not take demolition rates into consideration. Statistics Canada estimates the average life of warehousing buildings to be about 50 years. Thus, one may expect that in our estimates, the pre-1956 portion of the stock is somewhat overstated.

Another factor that has a bearing on the accuracy or validity of floor space estimates is the lack of data on some multiple-use buildings, parts of which may be used for storage but are often aggregated under an "other" or "miscellaneous" category of buildings. This factor effectively reduces the floor space estimate that is already at the lower bound due to the exclusion of vehicle storage and maintenance buildings from the scope of the study.

The qualifiers to the floor space estimate also apply to the estimated number of buildings because the number of buildings was computed on the basis of the floor space estimated for each province. Errors in floor space estimate would therefore be transferred to the number of buildings figure. Furthermore, to derive the number of buildings in each province from the floor space data, an average warehousing building size was used. Thus, the estimated number of buildings, which depends on another estimate and an average value, must be treated with less confidence than the floor space figures provided in this study.

In addition to cautioning against the indiscriminate use of estimates produced in this study, the above qualifiers highlight the need for further research. As discussed later in Section V, some of the estimates and distribution patterns obtained in this study can be refined, confirmed, or amended by further studies using appropriate sampling techniques.

EXHIBIT 5

DISTRIBUTION OF WAREHOUSE FLOOR SPACE BY TYPE OF WAREHOUSE*

PROVINCE/REGION	TYPE OF WAREHOUSE						ALL TYPES	
	DRY STORAGE		REFRIGERATED STORAGE - COOLER		REGRIGERATED STORAGE - FREEZER			
	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2
Atlantic Region	31,762	2,951	1,372	127	8,439	784	41,573	3,862
Quebec	118,936	11,049	9,117	847	12,202	1,134	140,255	13,030
Ontario	180,662	16,784	21,507	1,998	24,224	2,251	226,393	21,033
Manitoba	22,949	2,132	1,877	174	8,100	753	32,926	3,059
Saskatchewan	24,542	2,280	88	8	4,657	433	29,287	2,721
Alberta	82,728	7,686	452	42	7,233	672	90,413	8,400
B.C.	67,915	6,310	4,124	383	15,706	1,459	87,745	8,152
TOTAL	529,494	49,192	38,537	3,579	80,561	7,486	648,592	60,257

* Derived by using the results of a census of Public Warehouses undertaken by Statistics Canada (Catalogue # 63-212). The floor space surveyed by Statistics Canada comprises only 4.9% of the entire warehousing floor space. The results are thus likely to be biased especially if Public Warehousing has a storage type distribution pattern different from that of the Private Warehousing sub-sector which comprises the majority of warehousing buildings.

DISTRIBUTION OF WAREHOUSING FLOOR SPACE BY TYPE OF STORAGE

An estimated distribution of warehousing floor space in the dry goods, cooler and freezer storage categories was considered necessary because the building design characteristics and energy consumption patterns of these building types were expected to differ.

Method to Estimate Warehousing Floor Space Distribution by Type of Storage

The data published by Statistics Canada on 256 Public Warehousing Firms surveyed in 1976 was used (Appendix 5). The distribution percentage of warehousing floor space by storage type was calculated for each province. These percentages were then directly applied to the warehousing floor space estimated for each province in our study.

Estimated Distribution by Type of Storage - Warehousing

Exhibit 5, opposite, provides an estimated distribution of warehouse floor space in the dry goods, cooler, and freezer storage categories for the Atlantic Region and the provinces of Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia.

From Exhibit 5, it is clear that dry storage comprises 81.6% of total warehousing floor space. The highest concentration of dry storage area is shown in Ontario (34.1%) followed by Quebec (22.5%), Alberta (15.6%) and B.C. (12.8%). Freezer storage comprises about 12.4% of the national stock, whereas refrigerated cooler storage is a relatively minor component with a national average distribution of 6.0%.

Limitations to the Estimated Distribution by Storage Type

The above distributions by types of storage were

discussed with field experts. They are of the opinion that dry storage space should be significantly higher than 81.6%. It, therefore, appears that the distribution of storage types among Public Warehousing Buildings (i.e., those for which the principal business of their owners is the rental of space) is different from that of Private Warehousing (i.e., buildings owned or leased by manufacturers or merchandisers primarily to store their own goods).

The distribution data must therefore be re-examined in a future study using sampling techniques. Such a confirmation seems necessary in view of the fact that the floor space of Public Warehousing firms surveyed by Statistics Canada comprises only about 4.9% of all warehousing floor space. Secondly, the representativeness of the sample is questionable, given that Public Warehouses constructed for multiple tenant rentals may have storage type ratios different from those found in Private Warehouses.

DISTRIBUTION OF WAREHOUSING FLOOR SPACE BY SIZE CATEGORIES

This distribution was expected to provide supplementary information to enhance the physical profile of warehousing buildings.

Method to Calculate Distribution of Warehousing Floor Space by Size Categories

Data for the analysis was obtained from Canadata's data base which compiles data on an individual building basis. Warehousing buildings constructed in the period 1974-1981 were classified into five size groups. The number of buildings in each size group, by province, was first established and then converted into percentages. Similarly, the floor area of buildings in each size group, by province, was first established and then converted into percentages.

EXHIBIT 6

DISTRIBUTION OF WAREHOUSE FLOOR SPACE AND NUMBER OF BUILDINGS WHEN CLASSIFIED BY SIZE OF BUILDING: AN ANAYSIS OF 12,870 WAREHOUSES BUILT IN THE YEARS 1974-1981*

PROVINCE/TERRITORY	DATA DESCRIPTION	A UP TO 928m^{2}**	B 929 m^2 TO 1857 m^2	C 1858 m^2 TO 4644 m^2	D 4645 m^2 TO 13935 m^2	E 13916m^2 AND ABOVE	TOTAL PERCENTAGE
Yukon & N.W Territories	% of Floorspace	45.8	5.0	17.2	32.0	-	100
	(% of Buildings)	(92.0)	(2.0)	(4.0)	(2.0)	-	100
Nova Scotia	% of Floorspace	23.4	7.9	33.5	26.7	8.1	100
	(% of Buildings)	(78.0)	(6.4)	(11.6)	(3.4)	(0.6)	100
New Brunswick	% of Floorspace	22.8	13.4	19.0	34.0	10.8	100
	(% of Buildings)	(74.1)	(12.5)	(7.3)	(5.2)	(0.9)	100
Newfoundland	% of Floorspace	36.7	28.8	26.5	8.0	-	100
	(% of Buildings)	(76.4)	(15.7)	(6.8)	(1.1)	-	100
P.E.I.	% of Floorspace	68.5	10.2	11.7	9.5	-	100
	(% of Buildings)	(93.1)	(4.3)	(2.1)	(0.5)	-	100
Ontario	% of Floorspace	15.7	12.3	24.1	27.6	20.4	100
	(% of Buildings)	(64.2)	(15.5)	(13.3)	(5.8)	(1.2)	100
Quebec	% of Floorspace	21.9	12.2	21.9	27.0	13.0	100
	(% of Buildings)	(77.0)	(9.9)	(8.7)	(3.9)	(0.5)	100
Manitoba	% of Floorspace	18.1	14.6	30.2	23.5	13.4	100
	(% of Buildings)	(66.7)	(15.0)	(11.0)	(4.5)	(0.8)	100
Saskatchewan	% of Floorspace	35.9	26.4	25.0	8.9	3.8	100
	(% of Buildings)	(75.7)	(16.2)	(6.9)	(1.1)	(0.1)	100
Alberta	% of Floorspace	11.9	17.2	32.5	28.6	9.8	100
	(% of Buildings)	(68.1)	(23.6)	(20.1)	(7.4)	(0.8)	100
B.C	% of Floorspace	19.7	20.5	29.7	26.7	3.4	100
	(% of Buildings)	(59.6)	(21.3)	(14.1)	(4.7)	(0.3)	100
Canada	% of Floorspace	17.7	16.2	28.3	26.6	11.2	100
	(% of Buildings)	(63.2)	(17.5)	(13.6)	(5.1)	(0.6)	100

* Source: Canadata

** 1 square foot = .092903 square metre

A: less than 10,000 square feet, B: 10,000 f^2 to less than 20,000 f^2, C: 20,000 f^2 to less than 50,000 f^2, D: 50,000 f^2 to less than 150,000 f^2, E: 150,000 f^2 and above

Calculated Distribution By Size Categories - Warehousing

Exhibit 6, on reverse, provides a size-based profile of 12,870 warehouses found in Canadata's records of buildings constructed during the period 1974-1981. The distribution of warehouses by size does not follow a consistent pattern, although several provinces are similar in some respects. For example, the provinces of Nova Scotia, New Brunswick, Quebec, Manitoba, Alberta and British Columbia have 51-61% of their total floor area in the two size categories C and D. In these provinces, with the exception of Alberta and B.C., the smallest size group, A, is next in importance comprising 23-24% of total warehouse floor space. Ontario differs from other provinces in that 72.1% of its warehouse floor space is distributed in the larger size groups C, D, and E.

The Yukon and Northwest Territories as well as P.E.I., Newfoundland, and Saskatchewan have a higher percentage of floor space in the A size category.

Limitations to the Calculated Distribution of Warehousing Floor Space by Size Categories

The distributions have restricted validity in terms of the entire stock because they have been derived from data on buildings constructed in the period 1974-1981 only. Within those 8 years, the data showed no discernible trend, but this does not rule out the possibility of trends in previous periods of construction. Future demographic studies should confirm the applicability of these distribution percentages for periods of construction prior to 1974.

DISTRIBUTION OF WAREHOUSING FLOOR SPACE BY HEATING SYSTEM TYPES USED

This data is a supplement to the basic physical profile.

EXHIBIT 7

WAREHOUSE FLOOR SPACE DISTRIBUTED BY
TYPE OF HEATING SYSTEM: AN ANALYSIS
LIMITED TO CANADIAN BUILDINGS CONSTRUCTED BETWEEN 1974 AND 1981
AND HAVING THE HEATING FUEL TYPE SPECIFIED ON RECORD*

DATA	HEATING TYPE			
	GAS	OIL	ELECTRIC	TOTAL ANALYZED
# of Buildings	1,871	226	509	2,606
Floorspace in:				
1000 m^2	4,892	316	737	5,945
1000 f^2	52,661	3,405	7,929	63,995
Percentage Distribution of:				
# of Buildings	71.8	8.7	19.5	100
Floorspace	82.3	5.3	12.4	100

* Derived from Canadata records. Of all the warehouse buildings recorded as being constructed between 1974 and 1981, data was provided on the type of heating for only 34.3%. The results of the analysis of this 34.3% may, therefore, be biased.

Method to Calculate Distribution of Warehousing Floor Space by Heating System Types Used

The analysis involved summarizing the individual building data supplied by Canadata for the years 1974-1981. Three types of heating were specified - gas, oil and electric. The number of buildings and the floor space under each category were compiled. Also, the percentages of floor space and buildings distributed under each category were calculated.

Distribution by Heating System Types - Warehousing

Exhibit 7 on reverse, provides the results of the analysis of heating system types. In terms of both the number of buildings and total square footage, gas heating seems to be the predominant type. This is in line with the results obtained in a study by the Ontario Ministry of Energy for the province of Ontario.

Limitations to the Calculated Distribution of Warehousing Floor Space by Heating System Types

As shown in Exhibit 7, only 34.3% of all warehousing floor space could be classified by heating types. It is, therefore, necessary to determine through further gathering of sample data whether the 65.7% non-response has produced distortions or biases. Secondly, the applicability of the distribution percentages to all periods of construction may not be appropriate. Field experts are of the opinion that heating systems types have gradually changed over the years.

STOCK DATA (FLOOR SPACE AND NUMBER OF BUILDINGS) ON LIGHT INDUSTRIAL BUILDINGS

As in the case of warehousing buildings, an estimate of floor space of light industrial buildings and its distribution by periods of construction, major industrial groups and/or location were deemed to be

necessary to indicate the overall extent and materiality of the sub-categories, and to facilitate a targeted approach in the future both in terms of research and policy.

However, unlike the case of warehousing, floor space data on light industrial buildings did not form a basis for the estimation of energy consumption of these buildings. The energy consumption figures were estimated using the data collected by Statistics Canada, and the end-use energy consumption percentage figures synthesized from the reports of Ontario Hydro by MacDonald et al.

The number of buildings estimate was expected to serve the same purposes as in the case of warehousing buildings, namely to assist in the determination of an appropriate sample size for future empirical studies, and to assess the number of owners/users who might be reached to disseminate conservation measures being developed by the sector project.

Method to Estimate Light Industrial Building Floor Space and Number of Buildings

This method used data from several sources (see Appendix 5). It is similar to the method used for warehousing. The analysis was conducted at the national level for each major group of light industries because provincial data, except for that from Ontario and Quebec, was not available. The following steps were involved:

- Determining a low, medium and high per square foot cost for the years 1960-1981 (Appendix 7).
- Obtaining from Statistics Canada a rough estimate of the percentage of total investment in buildings that goes into the construction of light industrial plants as opposed to offices and warehouses. This step was necessary to avoid double counting the industrial warehouses already included in the warehouse building stock.

- Determining for some major groups containing both light and heavy manufacturing industries, the appropriate percentage allocation for "light" industries within the major group.

- Dividing the investment of each major group in light industrial buildings for a specific year by the medium per square foot costs for the year (Appendix 7). Repeating the same for the years 1961-1981.

- Obtaining from Statistics Canada publication, Fixed Capital Flows and Stocks, the value of building stock at the end of 1960, by major group.

- Apportioning to each major group the value of the pre-1961 building stock that would be applicable for buildings in the light industries within each major group.

- Dividing the apportioned value of pre-1961 light industrial building stock in constant 1971 dollars by the 1971 cost per square foot.

- Summing the pre-1961 square footage and the annual additions from 1961 -1981 to obtain the total stock.

- Repeating the entire procedure using appropriate data for the provinces of Ontario and Quebec.

- Determining the extent to which stock is understated due to reported values being only for buildings owned by the industries and thus excluding rental units.

- Dividing the estimated floor space of the universe of light industrial buildings by an average building size to obtain the number of buildings.

EXHIBIT 8

UNIVERSE OF OWNED AND RENTED LIGHT INDUSTRIAL BUILDINGS: NUMBER OF BUILDINGS AND FLOOR AREA ESTIMATED BY MAJOR INDUSTRIAL GROUPS

CODE SIC	MAJOR GROUP	NUMBER OF BUILDINGS		FLOOR SPACE		
		NUMBER	PERCENTAGE	1000 f^2	1000m^2**	PERCENTAGE
02	Tobacco	525	(3.0)	12,150	1,129	(2.9)
04	Leather	526	(3.0)	12,181	1,132	(3.0)
05	Textile*	917	(5.2)	21,229	1,972	(5.2)
06	Knitting Mills	286	(1.6)	6,631	616	(1.6)
07	Clothing	763	(4.1)	17,664	1,641	(4.3)
08	Wood*	2,678	(15.1)	62,014	5,761	(15.1)
09	Furniture and Fixtures	1,006	(5.7)	23,289	2,164	(5.7)
11	Printing, Publishing	2,475	(13.9)	57,314	5,325	(13.9)
13	Metal Fabricating*	1,757	(9.9)	40,689	3,780	(9.9)
14	Machinery	2,611	(14.7)	60,477	5,619	(14.7)
16	Electrical Products	2,570	(14.4)	59,513	5,529	(14.4)
20	Miscellaneous	1,678	(9.4)	38,857	3,610	(9.4)
	TOTAL Light Industrial	17,792	(100.0)	412,008	38,278	(100.0)

* All Process Energy Intensive Industries within the Major Groups have been included.

** Percentages of number of buildings do not vary from percentages of floor space because a single average size of building was used. See limitations.

Estimates of Stock Data - Light Industrial Buildings

Based on the information available during Phase I and the estimation procedures, detailed above, light industrial buildings were estimated to occupy a total floor space of 412,008,000 square feet or 38,278,000 square metres. These numbers reflect adjustments made for rented buildings. The total number of buildings were estimated to be in the order of 17,800 buildings. Exhibit 8, on reverse.

The distributions discussed in this sub-section are derived from the corporately owned portion of the building stock. Although Exhibits 9-11 provide an adjustment in the last column to include rented buildings, the age distributions are unadjusted. If future research shows that our adjustments are uniformly applicable to the different periods, then it will be possible to present an adjusted figure by periods of construction. However, in this study we have retained the original distribution by making no adjustments. CO (Corporately Owned) is hereafter prefixed to the term stock of light industrial buildings where the reference is only to that subset of the universe of light industrial buildings.

Exhibit 9, opposite, provides an estimate of the total magnitude of the floor area of light industrial buildings that are both corporately owned and rented. Of this 412,008,000 square feet (38,278,000 square metres) of total floor space, 70% is corporately owned.

The age distribution of the CO light industrial building by periods of construction is also presented in Exhibit 9. The table shows that 37.4% of CO light industrial building stock was built in the pre-1961 period, 38.2% in the 1961-1973 period and 24.4% in the two more recent periods, namely 1974-1978 and 1979-1981.

EXHIBIT 9

DISTRIBUTION OF FLOOR AREA OF CORPORATELY OWNED LIGHT INDUSTRIAL BUILDINGS IN CANADA BY MAJOR GROUPS AND PERIOD OF CONSTRUCTION AND THE UNIVERSE OF LIGHT INDUSTRIAL BUILDINGS (LIB)

SIC Code	MAJOR GROUP	Pre 1961		1961-1973		1974-1978		1979-1981		Corporately Owned Total Stock***		Estimated Universe of Owned and Rented LIB		
		1000 f^2	1000 m^{2**}	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	# of Buildings
02	Tobacco	4,588	426	2,557	238	870	81	490	46	8,505	791	12,150	1,129	525
04	Leather	5,583	519	1,990	185	591	55	363	34	8,527	793	12,181	1,132	526
05	Textile*	7,033	653	5,874	546	1,506	140	447	42	14,860	1,381	21,229	1,972	917
06	Knitting Mills	2,512	233	1,682	156	196	18	252	23	4,642	431	6,631	616	286
07	Clothing	7,797	724	2,756	256	1,152	107	660	61	12,365	1,149	17,664	1,641	763
08	Wood*	4,081	379	18,098	1,681	13,350	1,240	7,881	732	43,410	4,033	62,014	5,761	2,678
09	Furniture & Fixtures	6,653	618	6,429	597	2,085	194	1,135	105	16,302	1,514	23,289	2,164	1,006
11	Printing, Publishing	20,071	1,865	13,769	1,279	3,426	318	2,854	265	40,120	3,727	57,314	5,325	2,475
13	Metal Fabricating*	12,863	1,195	9,369	870	3,773	350	2,477	230	28,482	2,646	40,689	3,780	1,757
14	Machinery	12,627	1,173	16,294	1,514	7,637	710	5,776	537	42,334	3,933	60,477	5,619	2,611
16	Electrical Products	15,266	1,418	17,957	1,668	5,014	466	3,422	320	41,659	3,870	59,513	5,529	2,570
20	Miscellaneous	8,918	829	13,322	1,238	2,862	266	2,098	195	27,200	2,527	38,857	3,610	1,678
Total	Light Industrial	107,992	10,032	110,097	10,228	42,462	3,945	27,855	2,590	288,406	26,795	412,008	38,278	17,792

* All Process Energy Intensive Industries within the Major Groups have been excluded.

** 1 square foot = .092903 square metre.

*** THIS COLUMN AND THOSE TO ITS LEFT DO NOT SHOW THE UNIVERSE OF LIGHT INDUSTRIAL BUILDINGS. THE CORPORATELY OWNED BUILDINGS WERE ESTIMATED TO BE 70% OF THE UNIVERSE OF OWNED AND RENTED BUILDINGS.

Of the different major industrial groups, wood* (15.1%), machinery (14.7%), and electrical products (14.4%) occupy a large portion of the floor space of CO light industrial buildings. Other major space users are printing and publishing (13.9%), metal fabricating (9.9%) and miscellaneous (9.4%). The distribution of floor area in other major groups ranges from a low of 1.6% (knitting) to a high of 5.7% (furniture and fixtures). Since some industries may have more rented space than others, these distribution ratios may not be directly applicable if both rented and corporately owned stock are taken into consideration.

Exhibits 10 and 11 present a similar profile of floor space distribution of CO light industrial buildings by period of construction and major industrial groups for the provinces of Ontario and Quebec, respectively.

For Ontario, as shown in Exhibit 10, opposite, the floor space of CO light industrial buildings is concentrated in machinery (19.4%), electrical products (19.0%), printing and publishing (14.1%), miscellaneous (13.7%) and metal fabricating* (11.7%). The space distribution in Quebec is more evenly distributed among the different light industrial groups. The largest percentage of distribution is in electrical products (16.3%), followed by printing and publishing (13.6%). Metal fabricating*, textiles*, furniture and fixtures are similar in that the building space corporately owned by these industries ranges from 9.1% to 9.8% of corporately owned provincial stock. Distribution data for Quebec is summarized in Exhibit 11, opposite p. 33.

In terms of the national stock of corporately owned light industrial buildings, Ontario accounts for 52.5% and Quebec 24.9%. The two provinces thus account for 77.4% of CO stock of light industrial buildings. The strategic significance of these provinces in future research concerning energy conservation in light industrial buildings is, therefore, unquestionable.

EXHIBIT 10

DISTRIBUTION OF FLOOR AREA OF CORPORATELY OWNED LIGHT INDUSTRIAL BUILDINGS IN ONTARIO BY MAJOR GROUPS AND PERIOD OF CONSTRUCTION
AND
THE UNIVERSE OF LIB IN ONTARIO

SIC Code	MAJOR GROUP	Pre 1961		1961-1973		1974-1978		1979-1981		Corporately Owned Total Stock ***		Estimated Universe of Owned and Rented LIB	
		1000 f^2	1000 m^{2**}	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2
02	Tobacco	2,265	210	1,253	116	259	24	196	18	3,973	369	5,676	527
04	Leather	4,222	392	1,178	109	411	38	265	25	6,076	564	8,680	806
05	Textiles*	3,623	337	3,188	296	589	55	173	16	7,572	704	10,817	1,005
06	Knitting Mills	1,051	98	581	54	80	8	85	8	1,805	168	2,579	240
07	Clothing	2,342	218	519	48	761	71	326	30	3,948	367	5,640	524
08	Wood*	1,019	95	856	79	521	48	231	22	2,627	244	3,753	349
09	Furniture & Fixtures	3,166	294	2,926	272	708	66	600	56	7,400	688	10,571	982
11	Printing & Publishing	11,193	1,040	6,647	618	1,882	175	1,677	156	21,399	1,988	30,570	2,840
13	Metal Fabricating*	8,210	763	6,017	559	1,980	184	1,473	137	17,680	1,643	25,257	2,346
14	Machinery	10,017	931	12,122	1,126	4,081	379	3,251	302	29,471	2,738	42,101	3,911
16	Electrical Products	12,359	1,148	11,245	1,045	2,900	269	2,309	215	28,813	2,677	41,161	3,824
20	Miscellaneous	7,138	663	10,064	935	2,008	187	1,563	145	20,773	1,930	29,676	2,757
Total Light Manufacturing		66,605	6,189	56,596	5,257	16,187	1,504	12,149	1,130	151,537	14,080	216,481	20,111

* All Process Energy Intensive Industries within the Major Groups have been excluded

** 1 square foot = .092903 square metre

*** THIS COLUMN AND THOSE TO ITS LEFT DO NOT SHOW THE UNIVERSE OF LIGHT INDUSTRIAL BUILDINGS. THE CORPORATELY OWNED BUILDINGS WERE ESTIMATED TO BE 70% OF THE UNIVERSE OF OWNED AND RENTED BUILDINGS.

EXHIBIT II

DISTRIBUTION OF FLOOR AREA OF CORPORATELY OWNED LIGHT INDUSTRIAL BUILDINGS IN QUEBEC BY MAJOR GROUPS AND PERIOD OF CONSTRUCTION
AND
THE UNIVERSE OF LIB IN QUEBEC

SIC Code	MAJOR GROUP	Pre 1961		1961-1973		1974-1978		1979-1981		Corporately Owned Total Stock***		Estimated Universe of Owned and Rented LIBs	
		1000 f^2	1000 m^{2**}	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2	1000 f^2	1000 m^2
02	Tobacco	2,551	237	1,307	121	610	57	293	27	4,761	442	6,801	632
04	Leather	1,767	164	592	55	146	14	93	9	2,598	242	3,711	345
05	Textiles*	3,189	296	2,399	223	831	77	219	20	6,638	616	9,483	881
06	Knitting Mills	1,346	125	892	83	104	10	154	14	2,496	232	3,566	331
07	Clothing	4,088	380	1,673	155	310	29	175	16	6,246	580	8,923	829
08	Wood*	814	76	844	78	588	55	237	22	2,483	231	3,547	330
09	Furniture & Fixtures	2,585	240	2,734	254	915	85	307	29	6,541	608	9,344	868
11	Printing & Publishing	5,313	494	3,344	311	740	69	388	36	9,785	910	13,979	1,299
13	Metal Fabricating*	3,502	325	2,075	193	1,008	94	423	39	7,009	651	10,011	930
14	Machinery	1,954	182	1,734	161	1,722	160	944	88	6,354	591	9,077	843
16	Electrical Products	3,817	355	5,862	545	1,327	123	715	66	11,721	1,089	16,744	1,556
20	Miscellaneous	1,614	150	2,559	238	647	60	406	38	5,226	486	7,466	693
Total Light Manufacturing		32,540	3,024	26,015	2,417	8,948	833	4,354	404	71,857	6,678	102,652	9,537

* All process energy intensive industries within the major groups have been excluded

** 1 square foot = .092903 square metre

*** THIS COLUMN AND ALL THOSE TO ITS LEFT DO NOT SHOW THE UNIVERSE OF LIGHT INDUSTRIAL BUILDINGS. CORPORATELY OWNED BUILDINGS WERE ESTIMATED TO BE 70% OF THE UNIVERSE OF OWNED AND RENTED BUILDINGS.

The age distribution of floor area of CO light industrial buildings by period of construction in Ontario and Quebec are very similar. The pre-1961 stock comprises 44-45% in both provinces. The 1961-1973 stock in each province is 36-37% of corporately owned provincial stock, the corresponding number for the 1974-1981 stock being about 19%.

Limitations to Estimated Floor Space and Number of Light Industrial Buildings

As in the case of warehousing, the stock estimates of light industrial buildings are only first-cut estimates with a number of limitations arising from the kind of data used and procedures employed

The procedure adopted for stock estimation of light industrial buildings suffers from drawbacks similar to those affecting estimates of warehouse floor space. However, it avoids one of the weaknesses resulting from having to indirectly calculate the pre-1961 stock because the value of pre-1961 stock is available for each light industrial group. Hence, no surrogates were used to arrive at the pre-1961 stock of light industrial buildings.

However, the estimate of corporately owned and occupied light industrial buildings is only a subset of the universe of light industrial buildings. A comparison of the floor space for the period 1974-1981 estimated by using corporate investment data with floor space data accumulated by Canadata for the years 1974-1981, showed that depending on the province, the floor space was understated by 35 - 40%. It is, therefore, reasonable to assume that the Statistics Canada data of corporately owned light industrial buildings represents approximately 70% of the total of all light industrial buildings. Adjustments were therefore necessary. Since it would be erroneous to assume that the same adjustments are uniformly applicable to all time periods, it was decided that the age distributions were to be preserved as obtained from corporate investment data, and adjustments made only to the total floor space figures. The adjustment helped to

EXHIBIT 12

FLOOR SPACE OF LIGHT INDUSTRIAL BUILDINGS DISTRIBUTED BY SIZE CATEGORIES: AN ANALYSIS OF BUILDINGS CONSTRUCTED IN THE YEARS 1976-1981*

PROVINCE	DATA DESCRIPTION	A UP TO 928 m^{2}**	B 929 m^{2} to 1857 m^{2}	C 1858 m^{2} to 4645 m^{2}	D 4645 m^{2} to 13935 m^{2}	E 13936 m^{2} AND ABOVE	TOTAL PERCENTAGE
Nova Scotia	% of Floorspace	12.7	11.6	38.9	36.8	-	100
	(% of Buildings)	(58.5)	(13.8)	(20.0)	(7.7)	-	100
New Brunswick	% of Floorspace	17.0	12.6	24.3	46.0	-	100
	(% of Buildings)	(64.2)	(15.1)	(11.3)	(9.4)	-	100
Newfoundland	% of Floorspace	21.3	12.1	25.9	40.6	-	100
	(% of Buildings)	(67.4)	(13.0)	(10.9)	(8.7)	-	100
P.E.I.	% of Floorspace	12.5	32.9	33.2	21.4	-	100
	(% of Buildings)	(37.5)	(28.1)	(15.6)	(18.8)	-	100
Ontario	% of Floorspace	5.6	10.3	35.5	36.8	11.7	100
	(% of Buildings)	(35.5)	(21.8)	(27.3)	(13.9)	(1.5)	100
Quebec	% of Floorspace	13.4	12.6	25.7	35.6	12.6	100
	(% of Buildings)	(59.2)	(16.9)	(15.2)	(7.9)	(1.0)	100
Manitoba	% of Floorspace	15.7	23.0	24.2	29.0	9.1	100
	(% of Buildings)	(59.3)	(22.9)	(12.2)	(4.9)	(1.0)	100
Saskatchewan	% of Floorspace	17.2	21.0	25.4	15.2	21.2	100
	(% of Buildings)	(61.7)	(21.7)	(12.5)	(3.5)	(1.7)	100
Alberta	% of Floorspace	14.1	21.0	40.2	19.0	5.6	100
	(% of Buildings)	(52.2)	(27.0)	(16.0)	(4.6)	(0.3)	100
B.C.	% of Floorspace	17.8	18.2	35.7	20.6	7.7	100
	(% of Buildings)	(59.4)	(20.1)	(16.8)	(3.5)	(0.2)	100

* Source: Canadata

** 1 square foot = .092903 square metre

A: less than 10,000 square feet; B: 10,000 ft^{2} to less than 20,000 ft^{2}; C: 20,000 ft^{2} to less than 50,000 ft^{2}; D: 50,000 ft^{2} to less than 150,000 ft^{2}; E: 150,000 ft^{2} and above.

avoid the pitfall of substantial understatement. However, the validity of these adjustments must be confirmed in Phase II through sampling to determine the ratio of owned to rented light manufacturing buildings, by type of manufacturing, location and age.

DISTRIBUTION OF LIGHT INDUSTRIAL BUILDING FLOOR SPACE BY SIZE CATEGORIES

The size categories chosen for warehousing buildings were also used to study the size profile of light manufacturing buildings constructed in the years 1974-1981. The distribution was expected to provide supplementary information to the physical profile developed in this study.

Method to Calculate Distribution of Light Industrial Building Floor Space by Size Categories

The same method as for warehousing buildings was utilized. Data for analysis was provided by Canadata for the years 1974-1981.

Calculated Distribution by Size Categories - Light Industrial Buildings

The percentage distribution by size as shown in Exhibit 12, opposite, differs from the profile of warehouses (Exhibit 6) in that a greater percentage of light manufacturing buildings is found in the size categories C and D. The presence of higher concentrations of light industrial buildings in the C and D size categories, as compared to warehouses, is found in most provinces with the exception of B.C., Alberta and Manitoba. Thus in the C and D categories, the provinces of Nova Scotia, Ontario, New Brunswick, and Newfoundland have 75.7%, 72.3%, 70.3% and 66.5% of the light industrial buildings, respectively. Other provinces, with the exception of Saskatchewan, have 53-61% of light industrial buildings distributed in those two size categories.

Limitations to the Calculated Distribution of Light Industrial Building Floor Space by Size Categories

As in the case of warehousing buildings, the distribution estimates of light industrial buildings may not be extrapolated to periods of construction prior to 1974. Future studies, by using appropriate sampling techniques, will be able to study this issue and determine the applicability of size distribution estimates of more recent years to other periods of construction.

DISTRIBUTION OF LIGHT INDUSTRIAL BUILDING FLOOR SPACE BY HEATING SYSTEM TYPES USED

This distribution could not be provided because Canadata's records on heating system types in light industrial buildings suffered from a very high non-response rate.

This section provides a preliminary profile of energy consumption data on warehousing and light industrial buildings. Our review of building category profile studies, undertaken as part of energy conservation programs revealed that these studies aim at developing preliminary energy consumption figures. If direct fuel and electricity purchase data is not available, the only alternative is to use one or more energy consumption coefficients such as KWH/square foot/year or gigajoules/square metre/year. The total annual consumption figure must also be broken down by end uses, if possible, to assess the relative significance of end use categories and the potential impact of conservation measures upon each. Similarly, an analysis of fuel types used is expected to facilitate the evaluation of conservation measures in areas such as fuel substitution.

ENERGY CONSUMPTION DATA - WAREHOUSING

The profile of energy consumption developed for the warehousing sector was expected to assist in identifying significant areas for conservation. Given that in warehousing buildings relatively little appears to have been accomplished in terms of implementing energy conservation measures, it is likely that end uses that consume a large proportion of total energy may also offer good potential for increased conservation.

Method to Estimate Energy Consumption Within Warehousing

An indirect procedure was used to estimate the amount of fuel consumed within warehousing because direct fuel consumption (or purchase) data was not available. The method used energy coefficients by end-use category, in conjunction with floor space data, to estimate energy consumed for each end use identified, as well as the total energy consumed.

Estimated Energy Consumption Data - Warehousing

Exhibit 13, overleaf, provides a profile of the estimated energy consumption for space heating,

EXHIBIT 13

WAREHOUSES: ANNUAL FUEL CONSUMPTION ESTIMATES*** BY END USE AND BY PROVINCE

PROVINCES	NUMBER OF BUILDINGS	FLOOR SPACE		END USES									
				SPACE HEATING		LIGHTING		WATER HEATING		AUXILIARY		TOTAL	
		1000 ft^2	1000 m^{2**}	MWH	TERAJOULES*	MWH	TERAJOULES	MWH	TERAJOULES	MWH	TERAJOULES	MWH	TERAJOULES
Nova Scotia	1,322	14,274	1,325	228,384	822.2	92,781	334.0	7,137	25.7	99,918	359.7	428,220	1,541.6
New Brunswick	1,317	16,993	1,579	271,888	978.8	110,455	397.6	8,497	30.6	118,951	428.2	509,791	1,835.2
Newfoundland & P.E.I.	1,747	10,306	958	164,896	593.6	66,989	241.4	5,153	18.6	72,142	259.7	309,180	1,113.0
Quebec	12,987	140,255	13,030	2,244,080	8,078.7	911,658	3,282.0	70,128	252.5	981,785	3,534.4	4,207,651	15,147.5
Ontario	13,721	226,394	21,032	3,622,304	13,040.3	1,471,561	5,297.6	113,197	407.5	1,584,758	5,705.1	6,791,820	24,450.5
Manitoba	2,403	32,926	3,058	526,816	1,896.5	214,019	770.5	16,463	59.3	230,482	829.7	987,780	3,556.0
Saskatchewan	3,755	29,287	2,721	468,592	1,686.9	190,366	685.3	14,644	52.7	205,009	738.0	878,611	3,163.0
Alberta	4,784	90,413	8,400	1,446,608	5,207.8	587,685	2,115.7	45,207	162.7	632,891	2,278.4	2,712,391	9,764.6
B.C.	6,405	87,746	8,152	1,403,936	5,054.2	570,349	2,053.3	43,873	157.9	614,222	2,211.2	2,632,380	9,476.6
TOTAL****	48,441	648,594	60,255	10,377,504	37,359.0	4,215,863	15,177.1	324,299	1,167.5	4,540,158	16,344.6	19,457,824	70,048.2

* 1 MWH = .0036 Terajoules (10^{12})

** 1 square foot = 0.092903 square metre

*** sources used for estimating fuel consumption:

- Moffat Engineering Limited's study of 3 typical buildings
- Ontario Ministry of Energy: Commercial Model
- Engineering Interface, Report to the Royal Commission on Electric Power Planning

**** Excludes Yukon and Northwest Territories

Average energy consumption coefficients used were:

Space Heating	-	16.5 KWH/sq. ft./year
Lighting	-	6.5 KWH/sq. ft./year
Water Heating	-	0.5 KWH/sq. ft./year
Auxiliary	-	7.0 KWH/sq. ft./year
Total		30.0 KWH/sq. ft./year

lighting, water heating, and auxiliary uses within warehousing buildings in nine provinces. The total consumption figure of 70,048 terajoules, or 19,457,824 megawatt hours, should be considered as one of several feasible estimates. However, because of the nature of the energy coefficients used, the initial total energy consumption estimate is likely to be rather conservative. Data in Exhibit 13 indicates that on average about 53.3% of total energy consumption in warehousing may be attributed to space heating, 21.7% to lighting, 23.3% to auxiliaries and 1.7% to water heating.

Limitations to Estimated Energy Consumption Within Warehousing Buildings

The estimates provided above must be considered with a full understanding of the limitations of both the data points used and the computational method employed.

Firstly, the following average end use coefficients were used:

End Use	KWH/Sq. Ft./Year
Space Heating	16.0
Lighting	6.5
Water Heating	0.5
Auxiliary	7.0
Total	30.0

The above coefficients were very similar to the estimates developed by the Strategic Planning and Analysis Group of the Ontario Ministry of Energy, and to the average estimates provided by Moffat Engineering Limited, based on a study of three typical buildings, one each in Ontario, Quebec, and Alberta.

However, the use of the average coefficients shown above cannot be expected to produce highly accurate or valid results. This is primarily because the variability of energy consumption within warehousing buildings is extremely high. For example, the reports by Engineering Interface Limited and MacDonald Desfor and Miloff both mention that the KWH/square foot/year of energy consumed within warehousing could range from 14.7 to 144.0, with an average of 36.6. Similarly, two case studies by Moffat Engineering Limited have produced two different energy consumption coefficients of 31 KWH/square foot/year and 49 KWH/square foot/year, respectively.

Thus, our average of 30 KWH/square foot/year is only one of several possible average estimates. In addition to the variability in energy consumption coefficients, it is also important to realize that a small variance in such coefficients can create a significant difference in the total energy consumption figures. For example, if the 36.6 KWH/square foot/year average coefficient, suggested by MacDonald et al, were used, the warehousing sector would have been estimated to consume 23,738,540 MWH, or 85,458 terajoules. This difference represents an increase of 22% in the estimated amount of energy consumed.

Future studies should obtain actual energy usage data from a representative sample of warehousing buildings in order to refine the energy profile consumption developed in this study. Future research should also attempt to correlate per unit area energy consumption coefficients with parameters such as period of construction, presence of loading docks, size of building, height of building, and envelope characteristics. Disaggregated sample data must be used to find the proportion of buildings that belong to the relevant sub-categories such as warehouses with loading docks. The differentiated energy consumption coefficients must then be applied to the stock of floor space in each relevant sub-category. Finally, the consumption of all sub-categories must be summed to obtain the total energy consumption figures, and energy consumption by end-use figures, for the entire warehousing sub-sector.

DISTRIBUTION OF ENERGY CONSUMPTION WITHIN WAREHOUSING BY FUEL TYPES

This distribution could not be studied because no data was available on the fuels and electricity purchased by the warehousing buildings sub-sector.

ENERGY CONSUMPTION DATA - LIGHT INDUSTRIAL BUILDINGS

The energy consumption profiles of light industrial buildings are developed in greater detail than those of warehouses because macro energy purchase data by fuel types was available by industry and by province. Secondly, since detailed end use consumption ratios were available on an industry-by-industry basis, more elaborate profiles could be developed.

Method to Estimate Energy Consumption Within Light Industrial Buildings

The estimation of energy consumption involved converting the quantities of fuel purchased by each light industrial group into energy equivalents using appropriate conversion factors (see Appendix 6) provided by the Special Projects and Regional Statistics Section of Statistics Canada. In calculating the energy consumption of industrial groups containing both process-energy intensive and light industries (such as textile, wood, and metal fabricating) care was taken to eliminate the consumption of all process energy intensive industries within each such group. Thus, the energy consumption reported for textile*, wood*, and metal fabricating* represents the energy used by light industries within each of the three groups.

The total energy consumed estimated using the method described above was then broken down by end uses. This was accomplished by using the percentages of energy consumed by end use by each industry presented in the report of MacDonald et al, which in turn is a synthesis of two Ontario Hydro Surveys (see Appendix 8). The percentages were applied to the total energy consumed in order to develop end use consumption patterns.

EXHIBIT - 14

Non-Process Versus Total Energy
Consumption of Light
Industries in 1978: A Province by Province
Summary (Quantities in Terajoules)**

Light Industries		Data Descrip-tion	British Columbia	Alberta	Saskat-chewan	Manitoba	Ontario	Quebec	Atlantic Provinces	Unallocated Residual	Canada x
SIC CODE	MAJOR GROUP										
02	Tobacco	NPU***	--	--	--	--	xx	xx	--	--	xx
		(AU)***	--	--	--	--	(759)	(738)	--	--	(1497)
04	Leather	NPU	--	29.2	--	79.5	780.0	207.0	--	5.5	1101.2
		(AU)	--	(58)	--	(159)	(1560)	(414)	--	(11)	(2202)
05	Textile*	NPU	7.3	29.4	--	6.6	1548.3	1544.0	58.4	2.9	3196.9
		(AU)	(10)	(40)	--	(9)	(2121)	(2115)	(80)	(4)	(4379)
06	Knitting	NPU	--	--	--	44.5	892.8	1026.4	--	131.4	2095.1
		(AU)	--	--	--	(61)	(1223)	(1406)	--	(180)	(2870)
07	Clothing	NPU	41.5	--	22.3	137.6	450.1	846.3	5.0	78.7	1581.5
		(AU)	(67)	--	(36)	(222)	(726)	(1365)	(8)	(127)	(2551)
08	Wood*	NPU	1518.0	212.6	99.5	18.9	568.3	444.0	296.4	--	3157.7
		(AU)	(4103)	(575)	(269)	(51)	(1536)	(1200)	(801)	(--)	(8535)
09	Furniture & Fixtures	NPU	53.6	69.3	2.9	130.0	1324.7	951.3	50.7	29.6	2612.1
		(AU)	(94)	(122)	(5)	(228)	(2324)	(1669)	(89)	(52)	(4583)
11	Printing, Publishing	NPU	254.9	290.4	103.7	210.2	2273.8	1031.0	92.9	15.8	4272.7
		(AU)	(354)	(403)	(144)	(292)	(3158)	(1432)	(129)	(22)	(5934)
13	Metal Fabricating*	NPU	348.3	274.8	39.8	207.2	4211.8	1521.0	157.9	17.9	6778.7
		(AU)	(622)	(491)	(71)	(370)	(7521)	(2716)	(282)	(32)	(12105)
14	Machinery	NPU	322.7	377.2	163.8	302.4	3954.2	1148.4	19.4	6.3	6294.4
		(AU)	(717)	(838)	(364)	(672)	(8787)	(2552)	(43)	(14)	(13987)
16	Electrical Products	NPU	130.6	122.6	37.8	160.0	6723.2	2585.0	66.6	94.1	9919.9
		(AU)	(204)	(191)	(59)	(250)	(10505)	(4039)	(104)	(147)	(15499)
20	Miscellaneous	NPU	66.7	44.9	3.3	40.9	3107.3	1268.5	35.0	19.1	4585.7
		(AU)	(101)	(68)	(5)	(62)	(4708)	(1922)	(53)	(29)	(6948)
	All Light Industries	NPU	2743.6	1450.4	473.1	1337.8	25834.5	12572.9	782.3	401.3	45595.9
		(AU)	(6272)	(2786)	(953)	(2376)	(44928)	(21568)	(1589)	(618)	(81090)

* Excludes consumption of heavy manufacturing industries within major group.
** 1 Terajoule = 277778 KWH
*** (AU) = Energy consumed for all uses. NPU = Energy consumed for Non-Process uses.
-- Too small or zero.
x Energy totals may differ slightly from table to table due to rounding.
xx Not available.

Estimated Energy Consumption Data - Light Industries

The energy consumption data of light industries is presented in a more elaborate manner than warehousing. The three different profiles that could be derived using the same data sets and method are:

- Amount of energy used by each light industrial group for process and non-process uses.
- Energy consumption of each light industrial group classified by end use.
- Energy consumption of all light industries classified by end use, by province.

Estimated Consumption for Non-Process Uses Versus Total Energy Consumption - Light Industrial Groups

The end-use energy consumption characteristics are disaggregated at a broad level into non-process end uses and all uses. This data is shown in Exhibit 14, opposite, and can be studied from both provincial and light industrial group viewpoints. The separation of the non-process energy uses is particularly relevant because these uses deal with space heating, lighting, and make-up air (replacing contaminated air with clean and heated air). Although Exhibit 14 was prepared using a different data base, it corresponds well to the floor area estimates presented in Exhibits 9, 10, and 11. For example, Ontario consumes 56.7% of all non-process energy and has 52.5% of the floor space of light industrial building stock. Similarly, Quebec uses 27.5% of total non-process energy and has 24.9% of the floor area of the stock of light industrial buildings.

EXHIBIT 15

Energy Consumption for Non-Process
Versus Process Uses Light
Industries for 1978

SIC CODE	LIGHT INDUSTRIES MAJOR GROUPS	NON-PROCESS END USES						SUM OF NON PROCESS USE		PROCESS USE		RATIO NON-PROCESS / PROCESS	OTHER USES				TOTAL ENERGY CONSUMED	
		SPACE HEATING		LIGHTING		MAKE-UP AIR							MOTOR		TRANSPORTATION			
		MMBtu	Tera-** Joules	MMBtu	Tera-Joules	MMBtu	Tera-Joules	MMBtu	Tera-Joules	MMBtu	Tera-Joules		MMBtu	Tera-Joules	MMBtu	Tera-Joules	MMBtu	Tera-Joules
02	Tobacco	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
04	Leather	152,917	550.5	30,583	110.1	122,333	440.4	305,833	1,101.0	269,139	968.9	1.1	30,583	110.1	6,111	22.0	611,666	2,202.0
05	Textile*	510,834	1,839.0	36,500	131.4	340,556	1,226.0	887,890	3,196.4	60,806	218.9	14.6	133,778	481.6	133,778	481.6	1,216,252	4,378.5
06	Knitting	183,361	660.1	47,833	172.2	350,778	1,262.8	581,972	2,095.1	95,667	344.4	6.1	103,639	373.1	13,944	57.4	797,222	2,870.0
07	Clothing	226,750	816.3	85,028	306.1	127,556	459.2	439,334	1,581.6	56,694	204.1	7.7	102,972	586.7	49,611	178.6	708,611	2,551.0
08	Wood*	331,889	1,194.8	96,833	341.4	450,417	1,621.5	877,139	3,157.7	426,723	1,536.2	2.1	308,167	1,109.4	758,612	2,731.0	2,370,641	8,534.3
09	Furniture & Fixtures	140,000	504.0	89,083	320.7	496,362	1,786.9	725,445	2,611.6	318,167	1,145.4	2.3	114,556	412.4	114,556	412.4	1,272,724	4,581.8
11	Printing, Publishing	261,722	949.4	230,778	830.8	692,306	2,492.3	1,184,806	4,272.5	131,861	474.7	9.0	164,833	593.4	164,833	591.4	1,448,311	[illegible]936.0
13	Metal Fabricating*	537,943	1,936.6	201,722	726.2	1,143,140	4,115.3	1,882,807	6,778.1	739,695	2,662.9	2.5	169,834	1,331.4	369,834	1,331.4	3,362,170	12,103.8
14	Machinery	621,639	2,237.9	116,556	419.6	1,010,168	3,636.6	1,748,363	6,294.1	1,198,696	5,035.3	1.2	621,639	2,237.9	116,556	419.6	3,885,256	13,986.9
16	Electrical Products	665,806	2,324.9	473,584	1,706.9	1,636,001	5,889.6	2,755,391	9,919.4	947,167	3,409.8	2.9	473,584	1,706.9	129,167	465.0	4,305,309	15,499.1
20	Miscellaneous	540,389	1,945.4	173,695	625.3	559,695	2,014.9	1,273,779	4,585.6	405,306	1,459.1	3.1	135,111	486.4	115,833	417.0	1,930,029	6,948.1
	All Light Industries	4,155,252	14,958.9	1,560,195	5,688.7	6,929,312	24,945.5	12,644,758	45,593.1	4,849,921	17,459.7	2.6	2,618,696	9,427.1	1,974,835	7,109.4	22,108,211	79,589.5

* The consumption of all energy intensive industries in these major groups has been excluded so that Textile*, Wood*, and Metal Fabricating* represent only the light manufacturing industries within each major group.

xx End use breakdown not available.

** 1 Terajoule = 277.778 MMBtu

Estimated Energy Consumption by End Use and by Light Industrial Group

Exhibit 15, opposite, is an expansion of Exhibit 14. However, the analysis is at a national level for each light industrial group. This data, when studied in conjunction with floor area estimates for the universe of light industrial building stock (Exhibit 9), shows that on average the light industries consume 10.1 KWH/square foot/year for space heating, 3.8 KWH/square foot/year for lighting and 16.3 KWH/square foot for make-up air. Thus both make-up air and space heating are major uses.

Estimated Consumption by End Use by Province for all Light Industries

Exhibit 16, overleaf, presents data used in Exhibit 15 from the perspective of provinces rather than light industrial groups. This data, when studied in conjunction with floor area estimates shown in Exhibits 9, 10, and 11 again reveals consistency. For example, of all the energy used for space heating, Quebec consumes 27% and has 24.9% of the floor area of building stock in the light industrial category. Similarly, Ontario uses 57.8% of the energy used for space heating and has 52.5% of the floor space of light industrial buildings.

Limitations to Estimated Energy Consumption within Light Industrial Buildings

The energy consumption estimates for the light industrial buildings are more valid than those for the warehousing buildings. This is because there is a published source on fuel and electricity purchased for the light industrial groups. However, the estimates could be further improved by obtaining actual fuel consumption data. Also, the end-use percentages used in this study can be rendered more accurate by conducting a new survey and obtaining statistically valid end-use distributions by province and by industry. This survey would be particularly desirable because six years have elapsed since the completion of the Ontario Hydro surveys (PMA 75-6 and 76-1) that form the basis for the end use percentages.

EXHIBIT 16

BREAKDOWN OF ENERGY CONSUMPTION OF LIGHT INDUSTRIES BY PROVINCE AND BY END USE (1978)

PROVINCES	SPACE HEATING		LIGHTING		MAKE-UP***		TOTAL FOR NON-PROCESS END USES		PROCESS + MOTOR		OTHER USE		TOTAL NON-PROCESS PROCESS AND OTHERS	
	MWH	TJ	MWH	TJ	MWH	TJ	MWH	TJ	MWH	TJ	MWH	TJ	MWH	TJ
Nova Scotia	26,083	93.9	10,000	36.0	43,250	155.7	79,333	285.6	38,278	137.8	17,361	62.5	134,972	485.9
New Brunswick	28,806	103.7	10,611	38.2	50,611	182.2	90,028	324.1	60,944	219.4	43,528	156.7	194,500	700.2
Newfoundland	14,000	50.4	4,167	15.0	20,056	72.2	38,223	137.6	30,111	108.4	28,306	101.9	96,640	347.9
P.E.I.	3,556	12.8	1,361	4.9	4,583	16.5	9,500	34.2	4,306	15.5	833	3.0	14,639	52.7
Quebec	1,197,362	4310.5	431,584	1553.7	1,859,057	6692.6	3,488,003	12556.8	1,815,161	6607.1	450,500	1621.8	5,773,866	20785.9
Ontario	2,295,780	8264.8	891,973	3210.1	3,970,087	14292.3	7,159,840	25775.4	4,251,059	15303.8	826,195	2967.1	12,235,094	44046.3
Manitoba	119,195	429.1	48,000	172.8	204,617	735.9	371,612	1337.8	244,806	881.1	42,944	154.6	659,362	2373.7
Saskatchewan	42,189	152.6	16,028	57.7	72,972	262.7	131,389	473.0	98,833	355.8	34,500	124.2	264,722	953.0
Alberta	125,000	450.0	48,278	173.8	229,445	826.0	402,723	1449.8	279,667	1006.8	90,945	327.4	773,335	2784.0
British Columbia	261,139	940.1	88,611	319.0	412,361	1484.5	762,111	2743.6	573,223	2063.6	406,334	1462.8	1,741,668	6270.0
Total of Provinces**	4,113,310	14807.9	1,552,613	5589.4	6,866,039	24720.6	12,532,762	45117.9	7,416,590	26699.7	1,939,446	6982.0	21,888,798	78799.6

* 1 Terajoule (TJ) = 277.778 MWH

** Differs from total for Canada because of residual quantities not allocated to provinces and energy consumed by Tobacco Industries being an aggregate quantity not divisible by end use.

*** Primarily concerned with replacing air contaminated with dust, chemicals etc. with cleaned and heated air.

DISTRIBUTION OF LIGHT INDUSTRIAL ENERGY CONSUMPTION BY FUEL TYPES

This data was expected to provide a basis for future research on fuel substitution.

Method to Estimate Light Industrial Energy Consumption by Fuel Types

The method used data provided by Statistics Canada's publication - Consumption of Purchased Fuel and Electricity by the Manufacturing, Mining, Logging and Electric Power Industries. The analysis involved converting fuel quantities into terajoules or megawatt hours, and then calculating the percentage of each fuel type used by an industry in the context of total energy consumed.

Estimated Distribution by Fuel Types - Light Industries

The fuel type consumption characteristics of light industrial buildings presented in Exhibit 17, overleaf, reveal that natural gas and fuel oil constitute the major sources of energy. An analysis was also conducted on a province-by-province basis for each light manufacturing group (no exhibits). The analysis showed differences in the pattern of consumption for the same industry between different provinces. For example, the printing and publishing industry in Nova Scotia and New Brunswick uses two major fuel types: fuel oil (23.8 - 26.8%) and electricity (33.3 - 53.6%). However, in Ontario the same industry uses natural gas (43.2%) and electricity (34.5%) to a greater extent than fuel oil (7.7%). The fuel type distribution provided for each industry in Exhibit 17 thus only represents the average fuel type distribution for each industry.

Limitation to the Fuel Type Distribution Estimates

There are fewer qualifiers to the estimates because the quality of data used and the method employed are better than those used for other estimates of the study. However, it must be mentioned that a macro-data source has been used, and to that extent, the data will have limited use in subsequent research requiring disaggregated data. Furthermore, it would be desirable to relate fuel type data to end use consumption because we are primarily interested in fuel types used for non-process uses.

EXHIBIT 17

MEAN PERCENTAGE DISTRIBUTION BY FUEL TYPE OF ENERGY CONSUMED BY EACH LIGHT INDUSTRIAL GROUP***

Light Industries		**	FUEL TYPES								
SIC CODE	MAJOR GROUP	Data Type	Natural Gas	Coal & Coke	Gasoline	Kerosene	Diesel Oil	Fuel Oil	LPG	Electricity	TOTAL
02	Tobacco	Mean	29.1	-	4.7	0.1	0.4	31.5	1.1	33.0	100
		Range	24.6-31.6	-	4.6-4.8	0.0-0.4	0.0-1.2	28.8-36.7	1.0-1.2	30.7-35.4	
04	Leather	Mean	49.5	-	2.3	2.2	0.7	24.3	0.5	20.6	100
		Range	44.9-54.0	-	2.0-2.9	1.3-3.2	0.6-0.9	22.5-27.4	0.4-0.7	18.2-21.2	
05	Textile *	Mean	28.1	-	3.2	0.1	0.2	45.3	4.3	18.8	100
		Range	25.9-30.5	-	2.6-3.6	0.0-0.2	0.1-0.4	43.0-47.2	4.2-4.5	18.3-19.5	
06	Knitting	Mean	33.3	-	1.4	1.1	1.0	35.8	0.8	26.7	100
		Range	26.0-39.7	-	1.1-1.6	0.2-1.6	0.5-1.5	29.1-39.2	0.5-1.1	21.7-40.8	
07	Clothing	Mean	25.6	-	13.0	1.2	0.4	19.2	1.7	38.9	100
		Range	24.9-26.6	-	9.9-15.0	0.9-1.3	0.3-0.5	18.5-20.3	1.4-2.0	36.3-40.7	
08	Wood*	Mean	45.2	0.3	9.0	1.2	3.2	18.5	1.9	20.7	100
		Range	37.9-49.8	0.0-0.7	8.2-10.3	0.7-1.9	3.0-3.6	15.2-22.8	1.8-2.0	20.2-21.9	
09	Furniture & Fixtures	Mean	46.1	-	6.0	1.3	2.3	18.7	1.5	24.1	100
		Range	44.6-47.4	-	5.6-6.4	0.9-1.4	1.8-2.5	16.6-22.1	1.2-1.7	21.7-26.7	
11	Printing, Publishing	Mean	38.0	-	11.9	1.2	0.2	13.9	0.2	34.6	100
		Range	36.7-38.9	-	11.5-12.4	0.9-1.6	0.1-0.3	11.9-16.1	0.1-0.3	31.6-36.3	
13	Metal Fabricating*	Mean	53.2	0.3	8.4	0.9	2.5	14.1	1.9	18.7	100
		Range	51.4-56.7	0.0-0.6	8.1-9.1	0.6-1.2	2.1-3.1	8.6-17.3	1.4-2.4	17.2-20.2	
14	Machinery	Mean	53.3	0.8	4.9	0.5	1.0	12.8	1.9	22.7	100
		Range	53.8-56.6	0.6-1.0	4.6-5.2	0.3-1.0	0.9-1.1	12.7-13.0	1.6-2.2	21.5-24.0	
16	Electrical Products	Mean	49.1	0.5	1.5	0.2	0.3	16.0	2.3	30.3	100
		Range	45.6-51.5	0.2-1.2	1.4-1.6	0.1-0.4	0.2-0.4	12.8-20.9	1.9-2.5	28.4-31.9	
20	Miscellaneous	Mean	41.5	-	6.9	0.4	0.3	24.1	1.9	25.0	100
		Range	39.7-43.1	-	6.6-7.3	0.3-0.6	0.2-0.4	23.0-25.3	1.7-2.0	24.4-25.9	

* The consumption of heavy industries within these major groups have been excluded.

** Mean Percentage for years 1975-1978.

Range of percentages over the 1975-1978 period.

*** The data from Statistics Canada Publications (57-208) was first converted into terajoules using conversion factors specified in Statistics Canada Publication 57-003. The percentages were then calculated on the basis of total terajoules consumed by each industry.

This study has provided estimates of several key physical and energy consumption parameters of service industrial buildings comprising the Warehousing and Light Industrial Building sector.

The buildings in the sector, according to our estimate, cover a total floor space of over 1,060 million square feet or 98.5 million square meters. The total number of buildings is in the order of 66,000. Energy consumed annually by the sector for non-process uses is in excess of 115,600 terajoules, 32,122,583 MWH, or 0.11 Quads, as shown in Exhibit 18, overleaf.

The warehousing buildings sub-sector is estimated to occupy nearly 61% of the total floor space of the whole sector and accounts for nearly 61% of the total sectoral annual energy consumption for non-process uses. Since these estimates do not include vehicle storage buildings, nor some of the multiple-use buildings with storage components that are not readily identifiable, the estimates may be described as more representative of the lower bound of the warehousing sub-category.

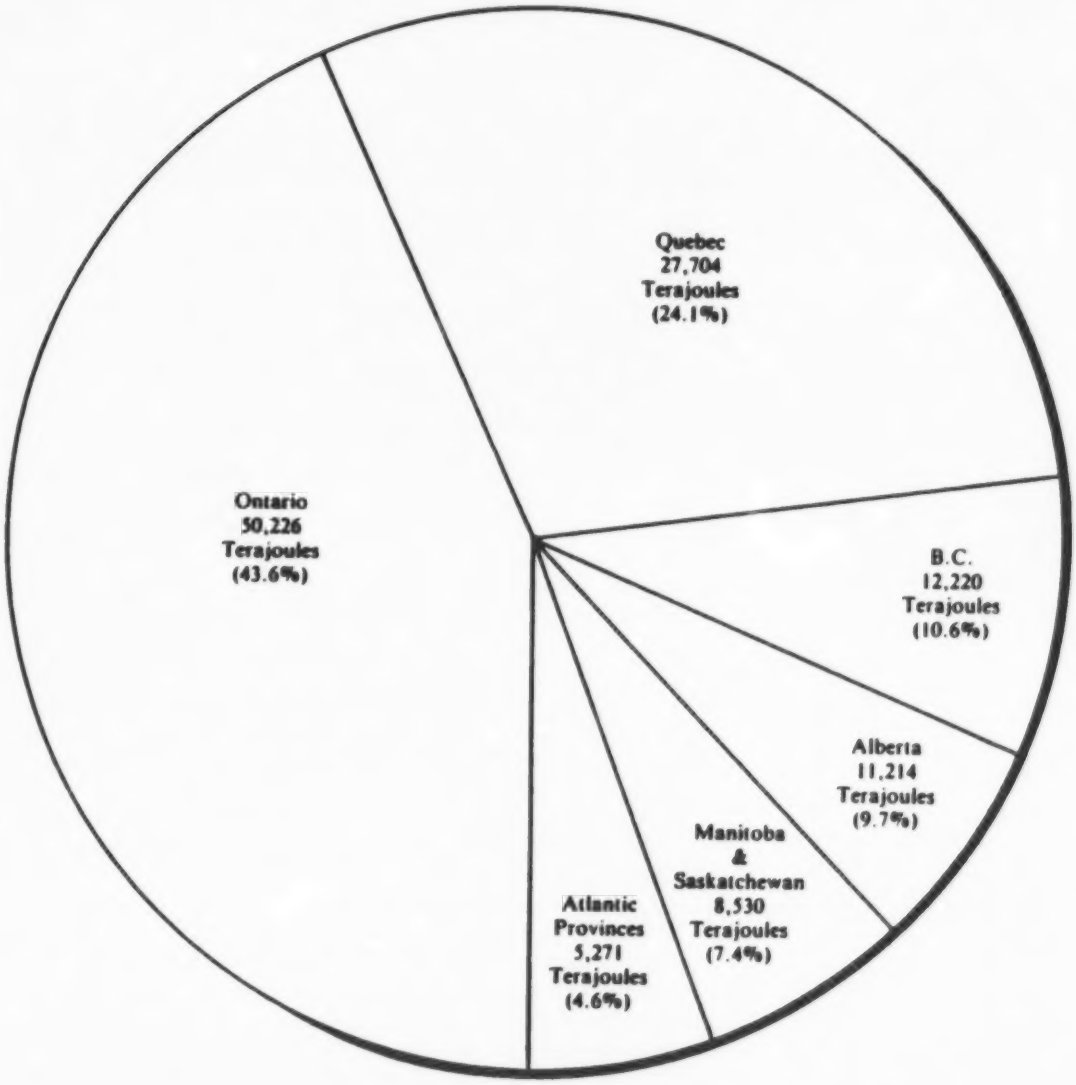
The light industrial building sub-sector is estimated to comprise nearly 39% of the total floor space of the sector. Light industrial buildings have also been estimated to account for a proportionate amount (39.4%) of the sector's annual non-process energy consumption.

The figures presented above have been developed using a variety of estimation techniques applied to data obtained primarily from Statistics Canada and Canadata. Research reports, field experts' opinions and the advice of professionals have contributed toward the initial delineation of a building category profile.

As indicated, neither the data sources nor the assumptions underlying estimation methods are considered infallible. However, some estimates are considered less valid or reliable than others. For example, the total floor space estimate of warehousing buildings, even though it excludes some buildings which could legitimately be included,

EXHIBIT 18

SUM OF NON-PROCESS
ENERGY CONSUMPTION OF
LIGHT INDUSTRIAL
AND WAREHOUSE BUILDINGS



appears to be based on more solid assumptions than the corresponding energy consumption estimates. Energy consumption in warehousing has been estimated using an average energy consumption coefficient per unit area, although there is actually a wide variation around that average figure. In the case of light industrial buildings, the energy consumption estimates (based on data obtained by Ontario Hydro in two surveys of fuel or electricity purchases and end-use energy consumption patterns) appear to rest on stronger foundations than the total floor space estimate because the proportion of corporately owned buildings to rented buildings is an unestablished factor in the case of the total floor space estimates of light industrial buildings.

The number of buildings estimated in both the warehousing and the light industrial sub-categories relies on the floor space estimate and on average building size calculated from buildings constructed in the years 1974-1981. The number of buildings is thus a derived statistic that should be treated with less confidence than the floor space estimates.

The above examples indicate that the initial building category profile has been developed with constraints on the availability of data and information and, as such, has some inherent weaknesses. These limitations do not, however, diminish the value of this initial demographic study nor its contribution toward furthering an understanding of the sector.

The study has thrown light on the macro-level physical dimensions of the sector and its energy consumption characteristics. It has also identified sectorally significant data about key geographic areas - the provinces of Ontario, Quebec, Alberta, and British Columbia - and key activity groupings - particularly dry storage warehousing and light industrial buildings in the wood*, machinery, electrical products, printing and publishing, metal fabricating*, furniture and fixtures, and miscellaneous industrial categories.

Additional research should focus on such strategically significant areas.

Within an increasingly focused scope, subsequent data collection and analysis tasks should attempt to:

1. Resolve some of the critical issues relating to this initial profile so that preliminary estimates can be amended or confirmed.

2. Further the advancement of the overall research project by obtaining additional information on buildings as the data requirements of other groups within the sector project team are specified.

With respect to the first task stated above, some examples of critical issues for consideration would be:

- To determine the proportion of corporately owned buildings within the universe of light industrial buildings, so as to confirm or amend initial estimates of floor space.

- To determine the proportion of dry storage within warehousing, so as to confirm or amend the suggested distribution which is based on a survey of Public Warehousing buildings only.

- To study buildings constructed prior to 1974 to determine the applicability of size distributions derived from Canadata's 1974-1981 records to the entire stock of warehouses and light industrial buildings.

- To update the end use energy consumption pattern obtained by Ontario Hydro and to study its applicability to other key provinces.

- To study heating system types installed in buildings in the various activity categories (warehousing and light industrial) by age and by province. This study would correct biases that may underly the distribution pattern of heating system

types set forth in this study. The pattern is suspect because it is confined to more recent buildings (1974-1981) and the data collection process produced a high non-response rate. The study would also clarify the light industrial buildings that were not considered for inclusion in heating type distribution due to lack of data.

- To estimate the size of vehicle storage buildings, and storage buildings that are part of multiple-use buildings, which legitimately belong to the sector, thereby improving estimates pertaining to sectoral stock data.

In addition to amending and confirming initial estimates, further research studies should also advance the frontiers of conservation research by obtaining disaggregated data through valid sampling techniques. Information must be gathered on characteristics such as: dimensions of buildings; physical condition of buildings; proportion of office, warehouse, and manufacturing space within each building in the sector; types of HVAC systems; special equipment used; lighting levels; presence or absence of types of loading docks in warehouses; temperature control; draught control; building envelope characteristics; doors and fenestration; numbers of employees; total energy consumed by fuel types; owner-renter contractual obligations and responsibilities; and barriers to conservation in each industry.

APPENDIX 1

RELEVANT PUBLISHED SOURCES OF DATA/INFORMATION

Relevant Published Sources of Data/Information

Acres Consulting Services Limited, Ontario Industrial Demand Study, February 1977.

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Statistics Canada, Consumption of Purchased Fuel and Electricity, By the Manufacturing, Mining, Logging and Electric Power Industries, Catalogue 57-208, Annual, July 1979.

Statistics Canada, Fixed Capital Flows and Stocks, All Provinces 1955-1981, Special Publication, July 1981.

Statistics Canada, Fixed Capital Flows and Stocks, Catalogue 13-211, Annual, September 1981.

Statistics Canada, Fixed Capital Flows and Stocks 1926-1978, Catalogue 13-568, Occasional, October 1978.

Statistics Canada, Manufacturing Industries of Canada: National and Provincial Areas, Catalogue 31-203, Annual, January 1982.

Statistics Canada, Manufacturing Industries of Canada: Sub-Provincial Areas, Catalogue 31-209, Annual, August 1980.

Statistics Canada, Private and Public Investment in Canada, Mid-year Review 1981, Catalogue 61-206, Annual, August 1981.

Statistics Canada, Public Warehousing, Catalogue 63-212, Annual, June 1978.

Statistics Canada, Quarterly Report on Energy Supply-Demand in Canada, 1980 - Part III, Catalogue 57-003, Quarterly, November 1981.

U.S. Department of Energy, Economic Analysis, Energy Performance Standards for New Buildings, January 1980.

U.S. Department of Energy, Federal Energy Management Program, Architects and Engineers Guide to Energy Conservation in Existing Buildings, February 1, 1980.

APPENDIX 2

SEPARATING THE MAJOR INDUSTRIAL GROUPS INTO LIGHT AND HEAVY CATEGORIES

SEPARATING THE MAJOR INDUSTRIAL GROUPS INTO LIGHT AND HEAVY CATEGORIES

In order to define the scope of Phase I research, it was necessary to systematically separate the light industries from the heavy industries.

It was decided that a two-step, successive screening method would be most appropriate. In the first step, appropriate levels of energy intensiveness were applied to filter out the major groups that are clearly intensive users of energy (heavy major groups).

The second screen involved a closer scrutiny of the borderline cases to include only those industries within the borderline major groups that are light in character.

Appropriate Indicators for Studying the Energy Intensiveness of Industrial Groups

A review of literature revealed that the following five indicators could be used to study the relative energy intensiveness of industries:

1. Energy consumed for space heating and lighting as percentage of total energy used.
2. Energy consumed for make-up air as a percentage of total energy used.
3. Energy consumed per unit dollar value of shipment.
4. Energy consumed per unit dollar value added.
5. Energy consumed per employee.

MacDonald et al (1979) have found that these indicators provide similar results. However, for our purposes, we decided to use indicators, 1 and 2 namely, the percentage of fuel consumed for space heating and lighting, and the percentage of fuel consumed for make-up air because they would enable the separation of light industries from process energy intensive industries (heavy industries).

The eighteen major groups of manufacturing industries were given a rank from 1 to 18 based on how high a percentage of energy was consumed for:

- Space heating and lighting.
- Make-up air.

The percentages were taken from the research report of MacDonald et al. For each of the two indicators, the group with the highest percentage was assigned the first rank and the one with the lowest was given the number eighteen. The two sets of rankings were then summed for each industry and the totals were each multiplied by four to convert them into ratings. Since both indicators were considered equally important, there was no need to apply differential weights to the ratings.

The following were the ratings obtained by the major groups:

Major Group	Ratings	Classification
Food and Beverage	104	Heavy
Plastic and Rubber	104	Heavy
Leather	24	Light
Textiles	96	Borderline
Knitting	40	Light
Clothing	8	Light

Major Group	Ratings	Classification
Wood	80	Borderline
Furniture and Fixtures	72	Borderline
Paper and Allied	128	Heavy
Printing and Publishing	24	Light
Primary Metals	120	Heavy
Metal Fabricating	88	Borderline
Machinery	64	Borderline
Transportation and Equipment	56	Borderline
Electrical Products	48	Light
Non-Metallic	136	Heavy
Chemical	136	Heavy
Miscellaneous	16	Light

From the ratings, it was evident that non-metallic industries, chemicals, primary metals, food and beverage, and plastic and rubber were clearly energy intensive (rating above 100). Similarly, clothing, miscellaneous, printing and publishing, leather and electrical products were clearly light (rating below 50). The borderline cases namely, transportation and equipment, furniture and fixtures, textiles, metal fabricating, machinery and wood were subject to further screening.

An examination of industries within the major groups and their energy intensiveness, measured by the same indicators as in screen 1, showed that a high proportion of the following major groups was light, and that the groups could be totally included in our study without any distortion of results:

- Machinery
- Furniture and fixtures

On the other hand, a majority of textiles, metal fabricating and wood were process energy intensive, thus warranting the exclusion of the process energy intensive components within the groups. Textile*, metal fabricating* and wood* were thus carved out of the major groups to represent only the light industry elements. The transportation and equipment group was excluded because the light components were not separable from those that were heavy.

Zoning by-laws were then studied to see whether their definition of light industries was similar. The exclusively light major groups and the light industries of borderline groups identified by our screening process corresponded with zoning law specifications for light industrial zoning. The tobacco industry, for which no end-use energy pattern was available, was included as light on the basis that it was classified as light industrial in zoning by-laws.

The light manufacturing groups defined for our study by the above procedure are given in the main text of this report.

APPENDIX 3

LIST OF CONTACTS - DATA SOURCING SURVEY

Mr. R.H. Arbuckle
Department of Municipal Affairs
Winnipeg

Mr. Bill Brennan
Toronto Area Industrial Development Board

Mr. David Brown
Toronto Real Estate Board

Mr. George Brown
Data Services Branch
Assessment Divison
Ontario Ministry of Revenue

Mr. M. Cavanaugh
Manufacturing and Primary Industries Division
Energy and Minerals Section
Statistics Canada

Mr. Simon Chamberlain
Planning and Development Department
Toronto City Hall

Mr. W. Chick
Advisor, Commercial Sector
Conservation Section
Ontario Ministry of Energy

Ms. Janet Connel
T.A. Connel Real Estate

Ms. Cheryl Currie
Canadian Industrial Development Corporation

Mr. Norman Davis
Energy Statistics and Strategy
Energy, Mines and Resources

Mr. Dave Dawson
Ontario Hydro

Mr. R. Drover
User Services Divison
Statistics Canada

Miss Janet Drummond
Conference Board of Canada

Mr. David Ellis
Senior Consultant
A.E. LePage

Mr. Gélinas
Wholesale and Retail Distribution Branch
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Mr. Gwartley
B.C. Assessment Authority
Victoria, B.C.

Mr. Jim Hooke
Energy, Mines and Resources

Ms. Catherine Kemp
Canada Mortgage Housing Corporation

Mr. D.G. Judd
City Assessor
Calgary

Mr. D.I. Kentish
Canadian Warehousing Association

Mr. Kingsley
Canadian Electrical Association

Mr. R.H. Arbuckle
Department of Municipal Affairs
Winnipeg

Mr. Bill Brennan
Toronto Area Industrial Development Board

Mr. David Brown
Toronto Real Estate Board

Mr. George Brown
Data Services Branch
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Energy Statistics and Strategy
Energy, Mines and Resources

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Ontario Hydro

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Ms. Catherine Kemp
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Mr. D.G. Judd
City Assessor
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Mr. D.I. Kentish
Canadian Warehousing Association

Mr. Kingsley
Canadian Electrical Association

Mr. B. Mazikins
Content and Analysis Branch
Housing Surveys and Dissemination Section
Statistics Canada

Mr. McColgan
Planning Department, City of Ottawa

Mr. McMurchie
Urban Community of Montreal

Mr. Steven Moore
A.E. LePage
Industrial Division

Mr. Gerry Nuttal
Research Division
Metro Toronto Planning Board

Mr. Bernard Payeur
Quebec Hydro

Mr. Jim Ransom
Canadata

Mr. Reimer
Department of Municipal Affairs
Winnipeg, Manitoba

Mr. J.T. Rogers
Energy Research Group
Carleton University

Mr. Rothman
Campeau Corporation
Ottawa

Mr. Sadler
City Assessor
Edmonton

Mr. D.S. Seymour
Capital Expenditure
Prices Division
Statistics Canada

Mr. Al Staruch
Transportation Services
Industry Branch
Industry, Trade and Commerce

Mr. R. Staveley
Special Projects
Statistics Canada

Mr. Duncan Taylor
Ontario Ministry of Energy

Mr. Vern Totten
Construction Division
Statistics Canada

Mr. John Tyler
Ontario Treasury Board

Mr. Drew Wilson
Building Research Division
National Research Council

Mr. Carl Wolf
Manager, Energy Affairs
Union Carbide Canada

Ms. Susanna M. Wood
National Wealth and Capital Stock Section
Statistics Canada

APPENDIX 4

DATA SOURCES AND THEIR CONTENT

EXHIBIT 19

ASSESSMENT AUTHORITIES/CITY PLANNING BOARDS

That May Provide Useful and Reasonably Accessible Data in The Near Future

Name	Physical Data Characteristics	Hurdles to Access	Data Retrievability
1. Metro Toronto Planning Board	• Main use/Activity • Floor Area • Date of Construction	Required a long turnaround time	Machine retrievable
2. City of Ottawa Planning Board	• Main use/Activity • Floor Area • Date of Construction	Time/manpower shortage	Manually retrievable
3. City of Calgary Assessment Office	• Main use/Activity • Floor Area • Date of Construction • Ownership • Location/Address	Policy and confidentiality related	Machine retrievable
4. City of Winnipeg Assessment Department	• Floor Area • Age	Policy, time and confidentiality related	Machine retrievable but only manual cards will be disclosed

Enquiries directed at several potential sources of data revealed that only some of the existing data bases would be accessible for Phase I. The main problems with accessing existing data bases were:

- Confidentiality of data
- Restrictive access policies
- Lack of machine retrievable sources
- Excessive turnaround time.

The highlights of our data sourcing efforts are briefly summarized below.

PHYSICAL DATA SOURCES

City planning boards, assessment authorities, private sector sources such as real estate firms, government departments, utilities, trade associations, and research agencies were contacted to determine physical data availability. Some useful sources for Phase I and Phase II were identified, and these are described below.

City Planning Departments/Assessment Authorities

Telephone enquiries, personal interviews or letters of request were addressed to officials in the research divisions of city planning boards and to assessment authorities. Some planning boards and assessment authorities had machine retrievable data or were willing to cooperate despite the absence of automation. Exhibit 19, opposite, summarizes the data available from the most promising sources identified.

The Planning Department of the Municipality of Metropolitan Toronto maintains building inventory data that is machine retrievable. The classification codes used by the agency were found to be extremely compatible with our data requirements. The department had no policy reservations about providing the data. However, the Phase I deadline

of March 31st was a major constraint, the department being unable to provide building inventory data before June 1982.

The data quality was acceptable and had only a few limitations:

- Some records were incomplete with respect to floor area and year of construction.
- In multiple-use buildings, the floor area occupied by the different tenants was not recorded, thus posing allocation problems.

The Planning Department of the City of Ottawa has floor space data, year construction, and a few other physical details on individually filed manual cards, each with a code number. Retrievability did not appear to be a major problem. A computerized list of building addresses, with use codes, is also available. From this list, it is possible to separate warehouses and light industrial buildings. The next step would be to read the card code corresponding to these buildings from the computer print out. The numbers will aid a quick manual draw of record cards with building data for analysis. Since the City of Ottawa is not large, data analysis can be completed reasonably quickly. The department is willing to manually retrieve the data, provided that sufficient time is allowed and the manpower costs are reimbursed. It is a good source for generating a stratified sample in Phase II.

The City of Calgary Assessment Office would be an excellent source of basic building data provided that a policy decision is made in favour of releasing aggregate data in a manner that will not violate confidentiality regulations. The data is use-coded, machine retrievable and does not seem to suffer from any major limitation.

A personal interview with the officers of the Winnipeg Assessment Department, followed up with a letter of request, did not produce any data for Phase I. But this source would be helpful in Phase II. The officials were reluctant to provide access

EXHIBIT 20

DATA COLLECTED BY THE RESEARCH DIVISION OF A.E. LEPAGE

MAJOR TYPES	SUB-CATEGORIES	LOCATIONS	CHARACTERISTICS	RETRIEVABILITY
o Warehouses	SIC 3 Digit	Edmonton, CMA Toronto, Calgary, Winnipeg, 50% of Vancouver	Address, Age, List of Tenants, Building Size, Expansion (size), SIC, Acreage on some	On Tape, Programmable
o Industrial Buildings	SIC 3 Digit	Metro Toronto, Vancouver, Calgary	Address, Age, List of Tenants, Building Size, Expansion (size), SIC, Acreage on some	On Tape, Programmable

to their computer print-outs as these contain some confidential data. A special project for extracting the required data in an aggregated form has yet to be negotiated.

In addition to the promising sources cited above, other assessment authorities were contacted. Data in their domain was found inaccessible for a variety of reasons and are described below:

1. The B.C. Assessment Authority has only a partly automated data base.

2. The Montreal Urban Community has data on manual cards only. The use-code is not totally relevant to the activity (manufacturing/storage/assembly) undertaken within the building. Since no separate files are maintained to identify building categories, retrievability would be a major problem.

3. The Ontario Ministry of Revenue Assessment maintains neither floor space data nor other building characteristics on their computer. The issue of confidentiality would need to be resolved before data could be made available.

Private Sector

Canadata, a Southam Marketing Service, maintains excellent basic building profile data for buildings constructed in the years 1974-1981. A customized report on such information was purchased as part of Phase I data collection. Appendix 5 on Data Collected contains details on this report.

A.E. LePage claims to have an extremely well developed and machine retrievable data base on warehousing and light industrial buildings. The content of their data base is shown in Exhibit 20, on reverse.

At our request, the company considered providing basic building data in aggregate form, but was unable to reach a policy decision on the conditions that must govern the release of building inventory data and, at present, the company has not agreed to supply any information.

The CIDC (Canadian Industrial Development Corporation), located in Ottawa, has about 100 record cards on light industrial buildings in the city. Campeau Corporation has a computerized data base on a number of industrial and warehouse buildings in Ottawa. These sources will be helpful in Phase II despite their inability to provide stock information for Phase I.

Government Department

Statistics Canada Officials were extremely cooperative in helping us identify relevant data on buildings. This source is discussed in detail under Data Collected.

ENERGY DATA SOURCES

Two major utilities, Ontario Hydro and Quebec Hydro, were contacted to explore the possibility of obtaining energy supply data. In general, Ontario Hydro was found to be extremely interested in energy conservation initiatives. Several research reports were identified, obtained and analyzed. Ontario Hydro is also in the process of creating a sophisticated data base. Its dual coding system will enable energy data to be classified by premises codes and SIC codes. Disaggregated data, however, will not be released due to policy constraints. Quebec Hydro advised us that the research studies prepared by Ontario Hydro were applicable to their situation and could be used in analysing Quebec data.

The gas utilities were not contacted because previous research, sponsored by the Canadian Electrical Association, to study data bases for the commercial sector found little in the way of a coordinated and comprehensive data base among gas utilities.

The sources used for energy data information analyzed during Phase I were:

- Statistics Canada
- The Ontario Ministry of Energy
- Moffat Engineering Limited
- Ontario Hydro.

Information from these sources is described in Appendix 5.

APPENDIX 5

DATA COLLECTED FOR THIS STUDY

This appendix describes the characteristics of major data sources that were used in this study.

CANADATA

The data base has a complete and disaggregated record of buildings constructed in Canada since 1974.

Floor space data on warehouses appears to be of excellent quality and the data available on a building by building basis allows valid size and geographic distributions to be determined for the period 1974 - 1981. However, heating-type data for the warehouses was found to be incomplete.

The data on light industrial buildings is gathered on the basis of use codes which are similar to SIC codes. This is a major advantage, that permits use of Statistics Canada's macro-level data for periods of construction not covered by Canadata without any significant change of sectoral definitions and boundaries.

We have used Canadata's report to:

- Study size distribution of warehouses by province.
- Study size distributions of light industrial buildings by specific activity (leather, knitting, clothing, etc.), and by province.
- Verify our stock calculations for the period 1974 - 1981 obtained by indirect estimation procedures, thus (to some extent) validating the indirect method.

Since Canadata's data base does not have an inventory of pre-1974 buildings, its usage is limited in terms of determining the total stock of

buildings under review. However, the data is extremely useful in studying distributions for the 1974 - 1981 period. This data base will also be helpful in Phase II to draw a stratified sample of warehouses and light industrial buildings constructed in the period 1974 - 1981. Details on how the data is collected and classified are provided below. The descriptions are mostly taken verbatim from Canadata's technical documentation.

How the Canadata Data Base is Developed

Information on much of the construction activity in Canada is gathered for Canadata and its sister divisions in Southam Communications Limited (Southam Building Reports, Daily Commercial News, Journal of Commerce) by a network of several hundred reporters across Canada. These reporters, grouped around offices in Montreal, Toronto, Winnipeg, Calgary, and Vancouver, are in constant contact with architects, consulting engineers, planning boards, municipal permit offices, developers, and many others who are responsible for construction activity. From these sources, the reporters obtain the details of most construction activity in the country.

As each building or engineering construction job starts, the following details are recorded in the Canadata data base:

1. Work start date.

2. Location of the construction job (Job site address; Municipality; Census Division; Province)

3. Nature of the job (New construction; Alteration or Repair; Addition to existing structure).

4. The use to which the building or engineering structure will ultimately be put (Structure-use category).

5. The dollar value of the construction required to complete the work (the contract award value, when available).

6. The square footage and number of storeys of each building.

7. The number of units such as dwelling units, hospital beds, classrooms, within each building, when appropriate.

8. The type of fuel which will be used to heat the building.

9. The presence or absence of air conditioning within a building.

10. The names and addresses of all specifiers working on the job (Architect; Civil/ Structural Engineer; Mechanical Engineer; Electrical Engineer; Project Manager; Construction Manager; Prime Contractor).

These details on construction jobs in both the planning and start stages pass through a rigorous editing and verifying system. Despite the complexities of the data gathering and checking system, information is obtained and processed very quickly.

The information thus gathered is then sent to the Canadata offices in Toronto.

The Canadata staff reconfirm and complete the details on each job, as required. The information is then coded and entered into the Canadata computer system. A further set of edit and imputation procedures screen the data before it is finally added to the Canadata data base.

All the information on construction jobs is added to the Canadata data base within two weeks after the month when work was started, or as soon as plans for a job become known. The data base is, therefore, very current. (Source: CANADATA TECHNICAL DOCUMENTATION).

STATISTICS CANADA

Our stock calculations of building floor area were mainly based on appropriately selected time series publications and special publications from Statistics Canada. These sources were supplemented by consultations with Statistics Canada officers. The estimation procedures employed are described in Sections 3 and 4. Here we provide a brief description of the time series publications that were selected and their content.

Construction in Canada is an annual time series published by Statistics Canada since 1953. In this publication, the value of all new construction work put in place is available by type of structure. Warehousing is defined to include all warehouses of the commercial and industrial sectors. New construction also includes additions, major renovations, and alterations that extend the life of a building.

The data on the value of construction by type is collected annually through two surveys by the construction division:

- Capital expenditures survey of all businesses (service, industrial, commercial, etc.).
- Survey of construction undertaken by government departments.

The data is available on a province-by-province basis except for Newfoundland and P.E.I. We used this data in the estimation of floor space of warehousing buildings.

Construction Price Statistics provides different types of price indexes. The light industrial building price index was particularly suitable in determining average costs per square foot of construction of light industrial buildings in current dollars for the years 1976 - 1981.

Private and Public Investment in Canada is a time series that goes back to 1961 for most light industrial groups. The data is available at a national level and for the provinces of Ontario and Quebec. The published time series provides a summary of capital expenditures on buildings incurred by all industries. This time series thus serves the same purpose for the light industrial sector that Construction in Canada serves for the warehouse sector, namely, to provide the value of annual additions to the stock of buildings. However, the value of light industrial buildings obtained from this time series is an understatement of the value of the universal set of light industrial buildings because only those buildings constructed and owned by companies in the light manufacturing sector are included in this publication. The rented factories are thus missing.

Fixed Capital Flows and Stocks 1926 - 1978 is a special publication that provides data at national and at provincial levels. The value of the gross stock of buildings under the different light industrial groups is the cumulative value of investment in buildings, less cumulative discards which takes account of stock retirement. The effective life of buildings in the different light industrial groups have been estimated by Statistics Canada as follows:

- Thirty years for knitting mills, furniture and fixtures, clothing, wood, and miscellaneous.
- Forty years for electrical products.
- Forty-five years for metal fabricating, machinery, and textiles.
- Fifty years for leather, printing and publishing and tobacco products.

For the warehouse sector, stock values are not available.

In addition to the time series publications mentioned above, Statistics Canada's census of Public Warehousing Firms was used to establish the proportion of dry goods, freezer and cooler storage space in warehouses. In this census, questionnaires were sent out to 256 public warehousing firms found in Statistics Canada's register of businesses which were classified to the warehousing industry. The census excluded private warehousing, wherein a manufacturer or merchandiser stored his own goods and no storage revenue was recorded. The results of this census, therefore, may not be representative of all warehousing and storage type buildings.

The Statistics Canada time series, Consumption of Purchased Fuel and Electricity, was used to determine the following energy related information on light industries:

- Total fuel consumed by each industry, by province.
- Proportion of fuel types consumed by each industry, at the national and provincial levels.

The time series provides quantities of fuels purchased only, and these require conversion into energy equivalents by using established conversion factors.

ONTARIO HYDRO

The end-use fuel consumption patterns of manufacturing industries have been studied by Ontario Hydro in two surveys (PMA 75-6 and 76-1). The consumption proportions identified in these surveys have been used to project end-use energy consumption patterns in this study.

ONTARIO MINISTRY OF ENERGY

The Ontario Ministry of Energy has studied the end-use energy consumption of warehouses. Their results were found to be similar to those obtained by Moffat Engineering Limited in their study of three typical warehouse buildings, one each in Ontario, Quebec, and Alberta.

APPENDIX 6

ENERGY CONVERSION FACTORS UTILIZED

Energy conversion factors utilized are as follows:

Fuel type	Natural Unit	Conversion factor
Coal:		terajoules
Anthracite	kilotonnes	29.53
Imported Bituminous	kilotonnes	29.99
Canadian Bituminous	kilotonnes	29.30
Sub-bituminous	kilotonnes	19.76
Lignite	kilotonnes	15.35
Coke	gigalitres	28.83
Coke oven gas	megalitres	18.61
Propane	megalitres	25.53
Butane	megalitres	28.62
Ethane	megalitres	18.36
Crude oil	megalitres	38.51
Still gas	megalitres	41.73
Motor gasoline	megalitres	34.66
Kerosene	megalitres	37.68
Diesel	megalitres	38.68
Light fuel oil	megalitres	38.68
Heavy fuel oil	megalitres	41.73
Petroleum coke	megalitres	42.38
Aviation gasoline	megalitres	33.52
Aviation turbo fuel	gigalitres	35.93
Natural gas	gigalitres	37.23
Electricity	gigawatt hours	3.60
Steam	kilotonnes	2.75

1 B.T.U. = 1.054 615 x 10^3 Joules

1 KWH = .0000036 Terajoules

Kilo = 10^3

Mega = 10^6

Giga = 10^9

Tera = 10^{12}

Source: STATISTICS CANADA
Energy Supply-Demand in Canada.

APPENDIX 7

CONSTRUCTION COST PER SQUARE FOOT

Construction Cost per Square Foot

The attached Chart provides a summary of per square foot construction costs for warehouses and light industrial buildings for the years 1953-1981. Several sources of information were used (see footnotes to chart on following page). Since construction costs vary by location, height of building, quality of construction, etc., it was decided that a low, medium and high cost series should be devised. Starting with actual costs for 1981, a construction cost index designed specifically for light industrial buildings was used to obtain the unit cost figures for the years 1953-1981.

The cost figures were crucial in the determination of floor space. Statistics Canada has a time series publication on the value of warehouse construction put in place, and another time series on the value of investment in building construction by light manufacturing industries. In the absence of retrievable and available building inventory data, the two time series of Statistics Canada provided the bases for floor space estimates. However, to convert dollar values for a particular year into floor space area constructed during the year, it was necessary to establish for each year a unit cost figure that would produce the best estimate of floor area.

A verification procedure was used to compare floor space estimated by using low, medium and high unit costs with actual floor space data compiled by Canadata for the years 1974-1981. Results showed that in the case of warehousing the best estimate was obtained by using the medium cost figures.

APPENDIX 7

Average Construction Cost
Per Square Foot for
Light Industrial Buildings and
Warehouses (Current Dollars)

Years	Light Industrial Buildings			Warehouses		
	Low	Medium	High	Low	Medium	High
1981	22.00	34.00	43.00	16.00	25.40	31.00
1980	19.69	31.43	38.82	14.31	23.48	27.98
1979	17.31	27.58	33.48	12.59	20.60	24.13
1978	16.65	24.66	30.44	12.10	18.42	21.94
1977	16.47	23.24	28.69	11.98	17.36	20.69
1976	15.84	22.94	27.67	11.05	16.00	19.95
1975	14.38	20.82	25.11	10.03	14.53	18.11
1974	13.01	18.84	22.73	9.07	13.15	16.39
1973	11.23	16.27	19.62	7.83	11.35	14.15
1972	10.31	14.92	18.00	7.19	10.41	12.98
1971	9.56	13.84	16.69	6.66	9.66	12.04
1970	8.79	12.74	15.36	6.13	8.89	11.08
1969	8.08	11.70	14.11	5.63	8.16	10.17
1968	7.62	11.03	13.31	5.31	7.70	9.60
1967	7.23	10.47	12.62	5.04	7.30	9.10
1966	6.83	9.88	11.92	4.76	6.90	8.60
1965	6.46	9.36	11.29	4.51	6.53	8.14
1964	6.18	8.94	10.79	4.31	6.24	7.78
1963	5.90	8.54	10.30	4.11	5.96	7.42
1962	5.72	8.28	9.99	3.98	5.77	7.20
1961	5.64	8.17	9.85	3.93	5.69	6.98
1960	5.59	8.10	9.77	3.90	5.65	7.00
1959	5.43	7.86	9.48	3.78	5.49	6.83
1958	5.24	7.59	9.15	3.65	5.29	6.60
1957	5.10	7.39	8.92	3.56	5.16	6.43
1956	4.94	7.16	8.63	3.45	4.99	6.22
1955	4.76	6.89	8.32	3.32	4.81	6.00
1954	4.67	6.76	8.15	3.25	4.71	5.88
1953	4.64	6.71	8.10	3.23	4.69	5.83

Note: Derived from consultation with experts and information from:

- Yardsticks for Costing
- Mr. D.S. Seymour
  Prices Division
  Statistics Canada
- Statistics Canada's publications on the factory model (Construction Price Statistics)
- Hanscomb Roy Associates

APPENDIX 8

END USE ENERGY CONSUMPTION PERCENTAGES FOR THE LIGHT INDUSTRIAL GROUPS

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SIC	MAJOR GROUP	SPACE HEATING	LIGHTING	MAKE-UP AIR	PROCESS	MOTOR	TRANSPORTATION	TOTAL
17	Leather	25	5	20	44	5	1	100
18	Textiles*	42	3	28	5	11	11	100
23	Knitting	23	6	44	12	13	2	100
24	Clothing	32	12	18	8	23	7	100
25	Wood*	14	4	19	18	13	32	100
26	Furniture & Fixtures	11	7	39	25	9	9	100
28	Printing & Publishing	16	14	42	8	10	10	100
30	Metal Fabricating*	16	6	34	22	11	11	100
31	Machinery	16	3	26	36	16	3	100
33	Electrical Products	15	11	38	22	11	3	100
39	Miscellaneous	28	9	29	21	7	6	100

* Excludes heavy industries within the major industrial groups

** Source: Ontario Hydro PMA 75-6, 76-1,
MacDonald, Desfor, Miloff, 1979
and some derivations for Textile*, Metal Fabricating* and Wood*

POOR

QUALITY

ORIGINAL